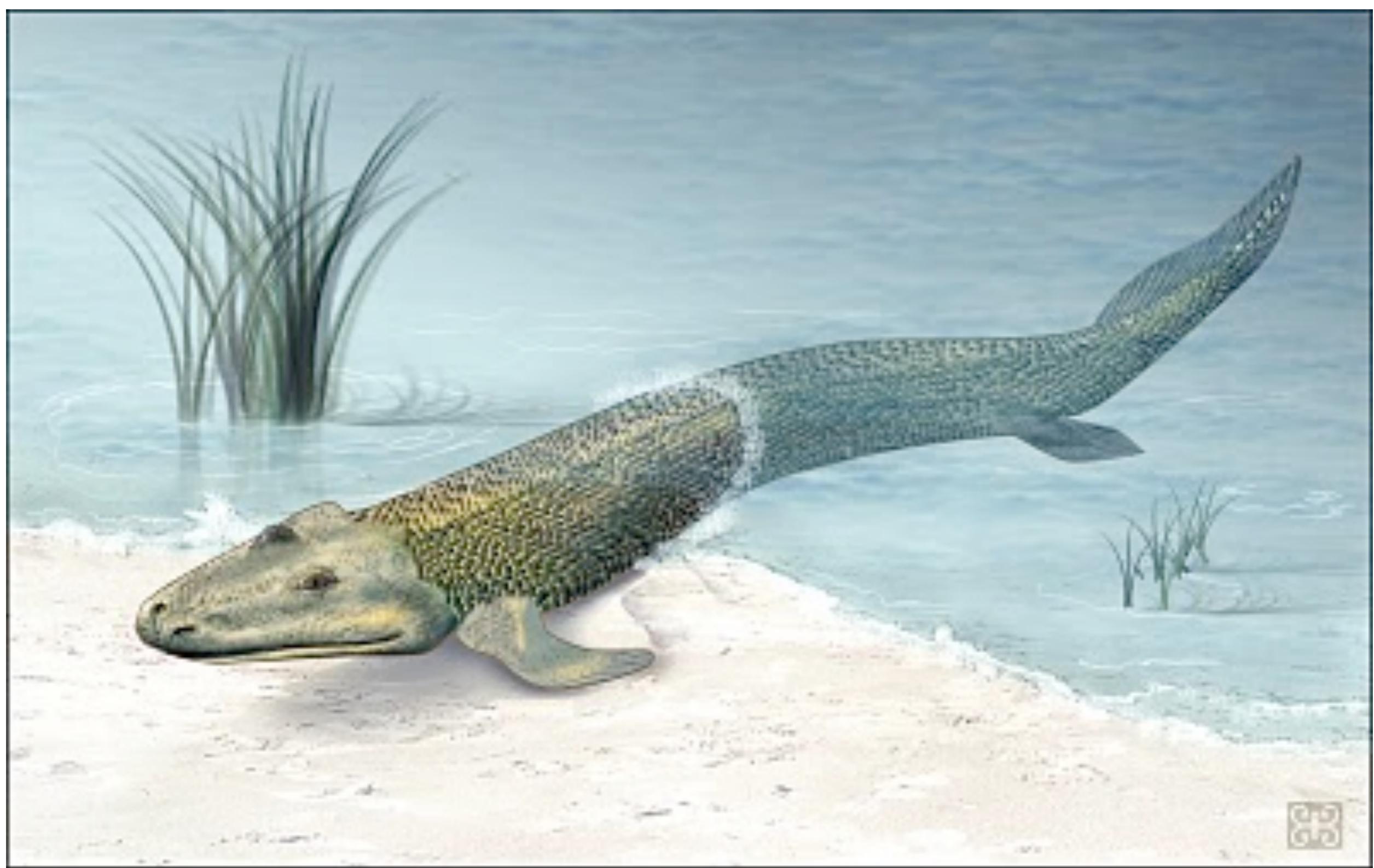


# Origins of herps

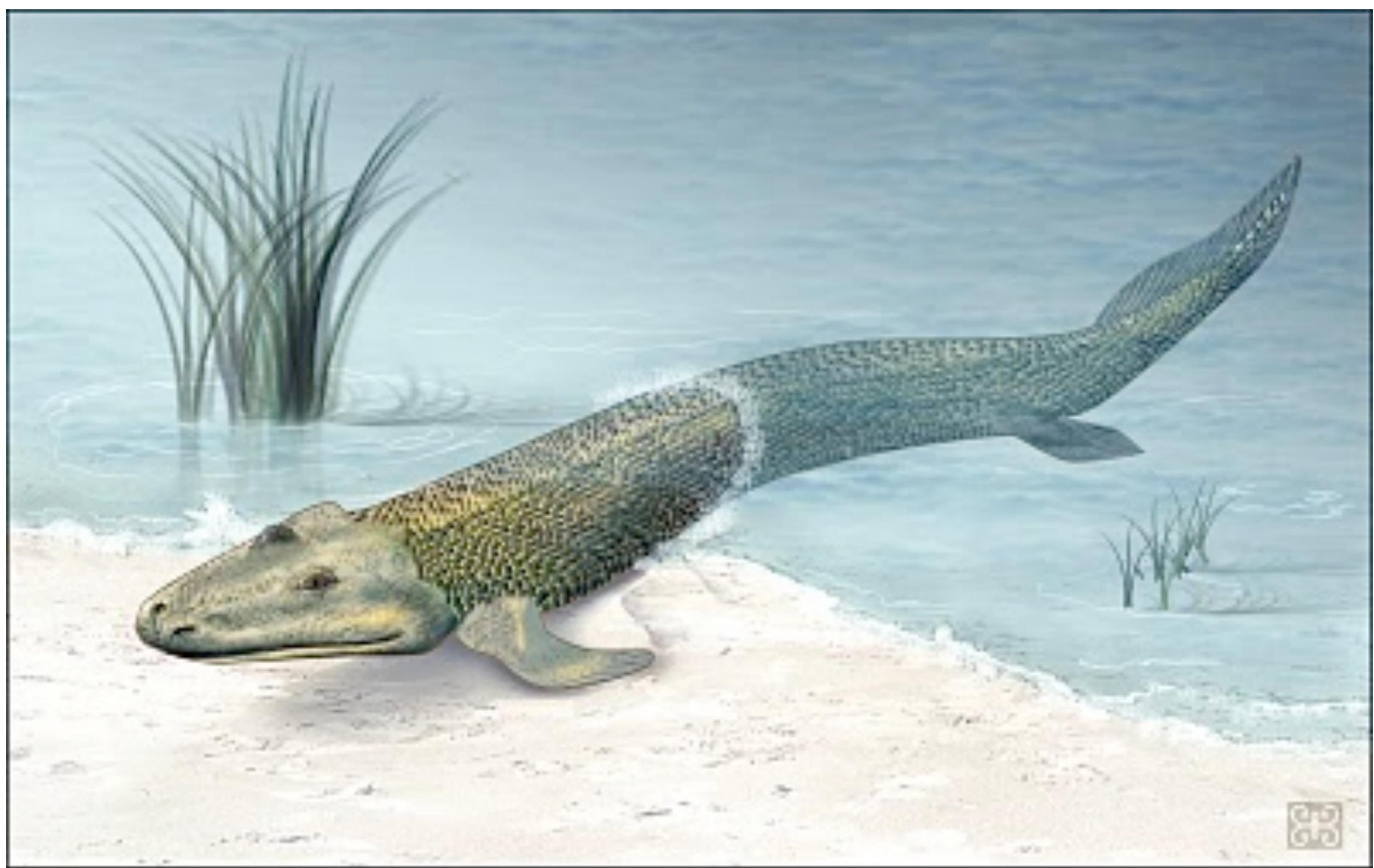
Herpetology  
28 August 2017



# Things you might think about the transition to land

**Legs** evolved for locomotion on land

**Lungs** evolved for breathing on land





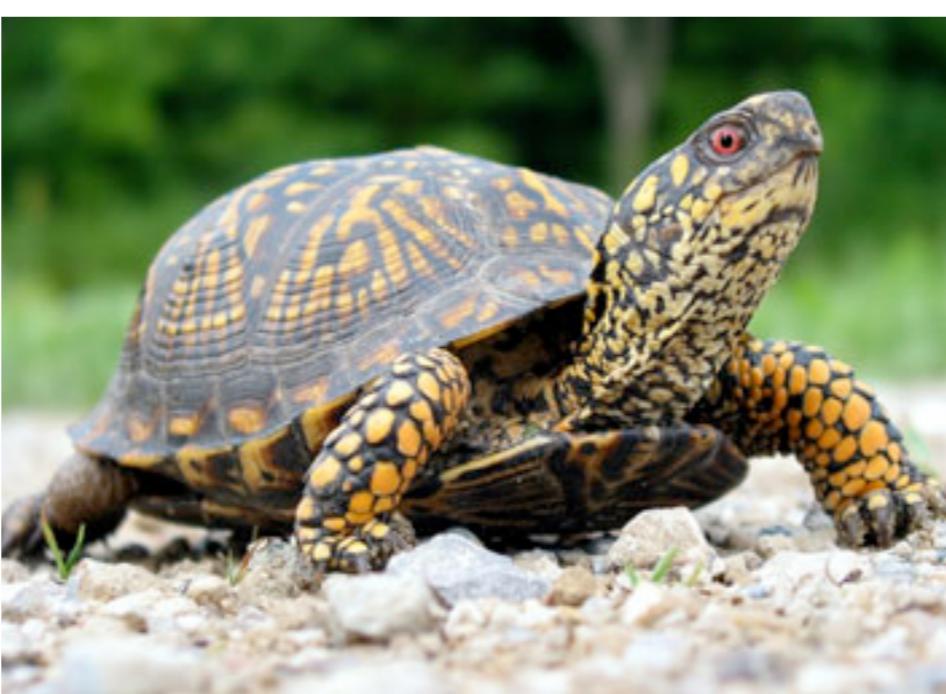


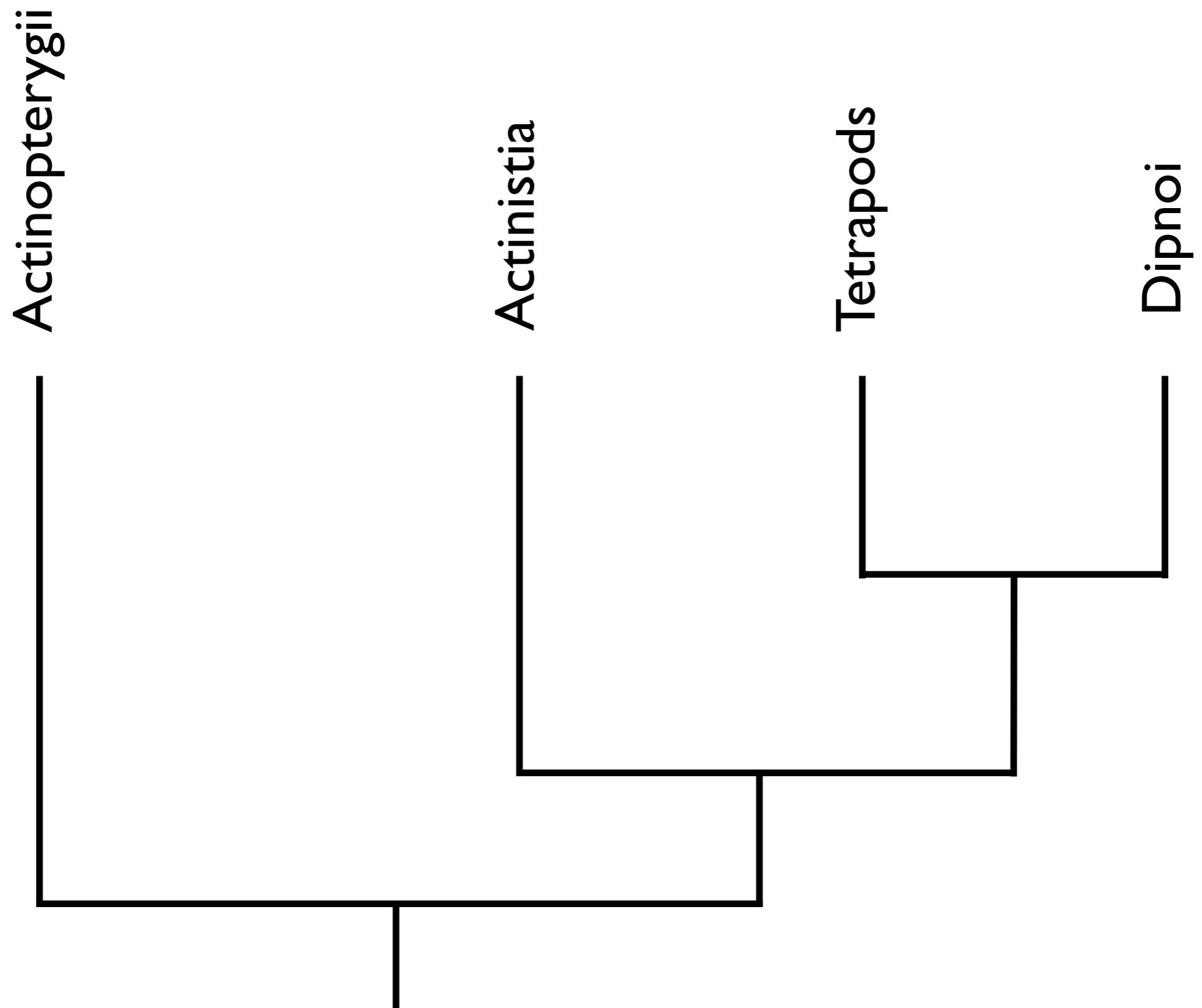
# How do we learn about the origin of herps?

- Study relationships among living species
- Find and analyze fossils
- Understand genetics and development

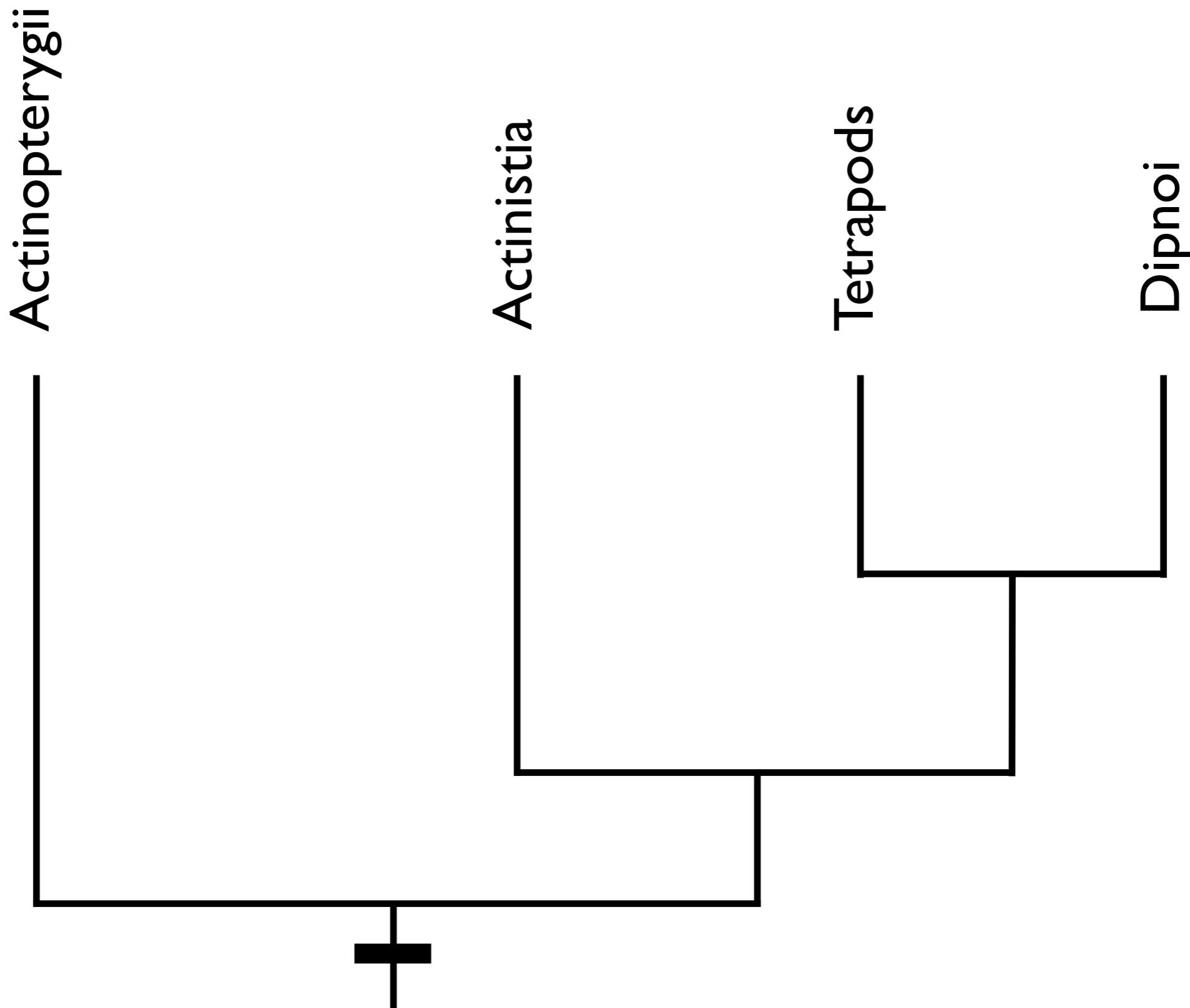
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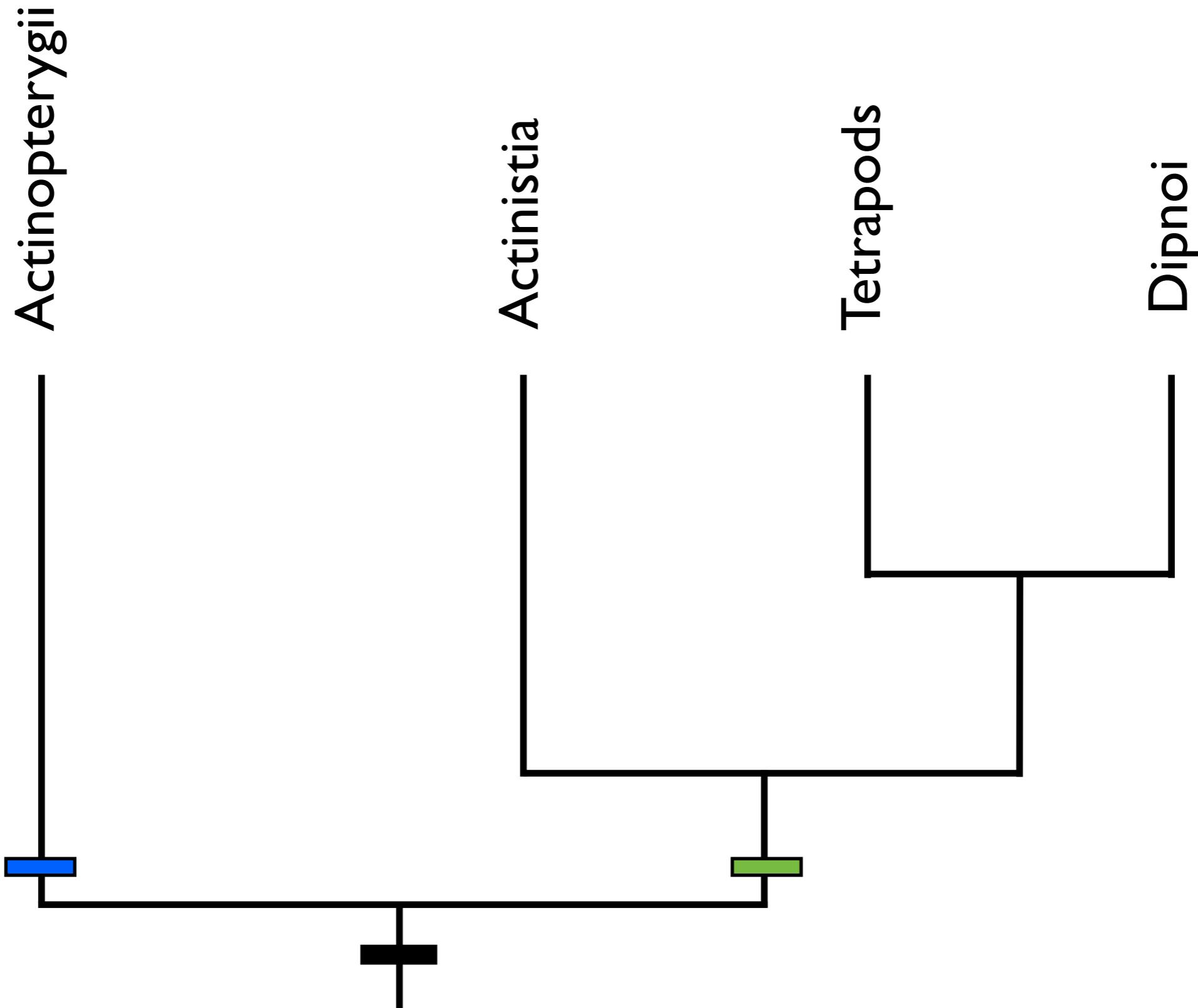


# Osteichthyes (bony fishes)

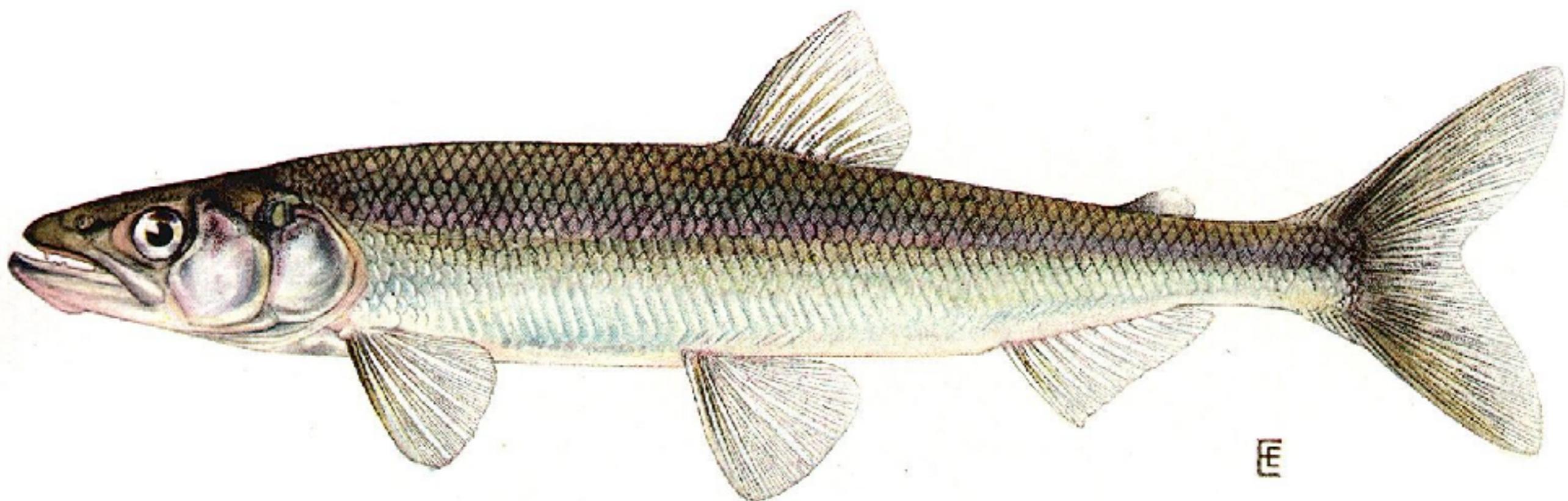


# Osteichthyes (bony fishes)

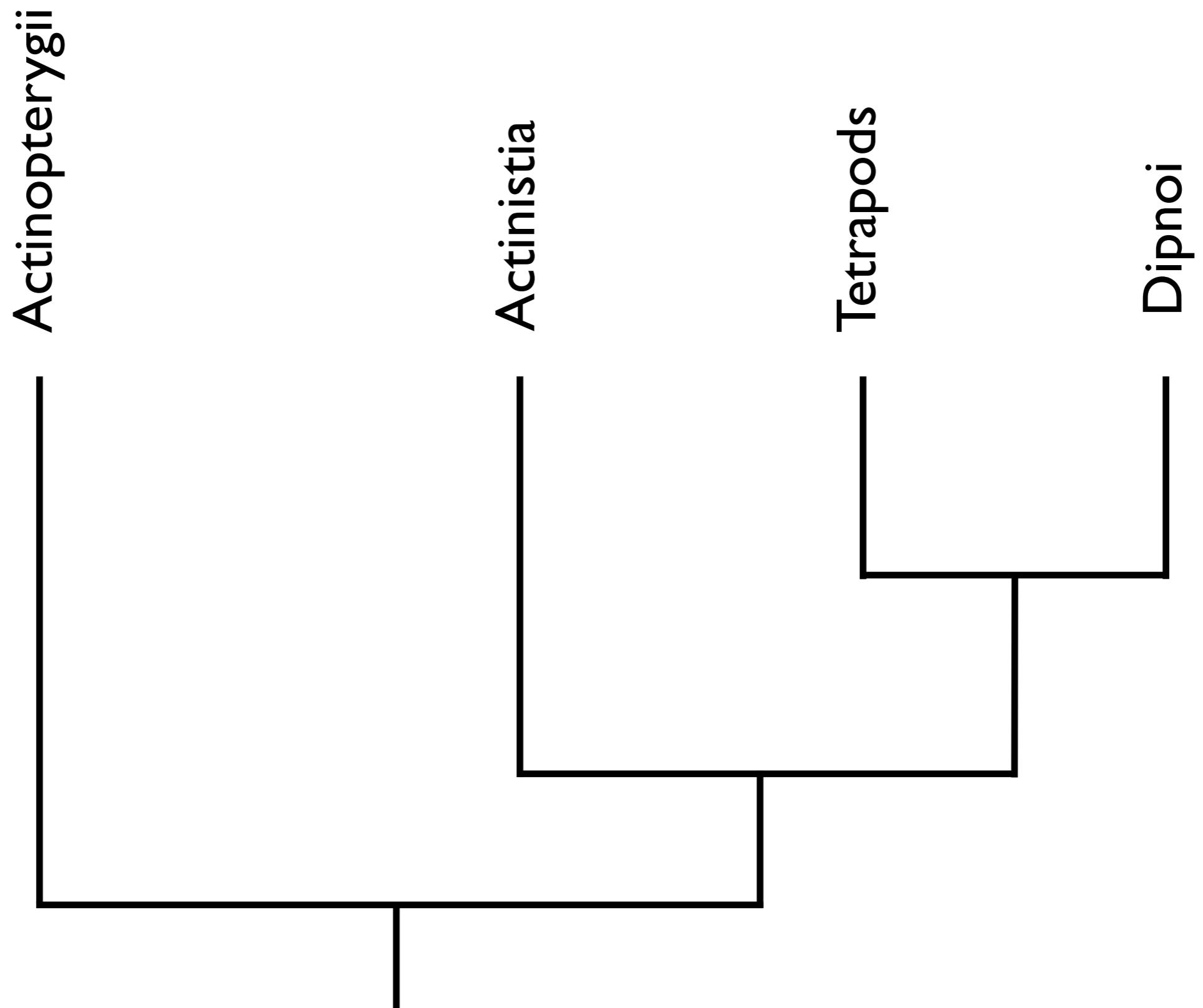
= Actinopterygii (ray-finned fishes) + Sarcopterygii (lobe-finned fishes)



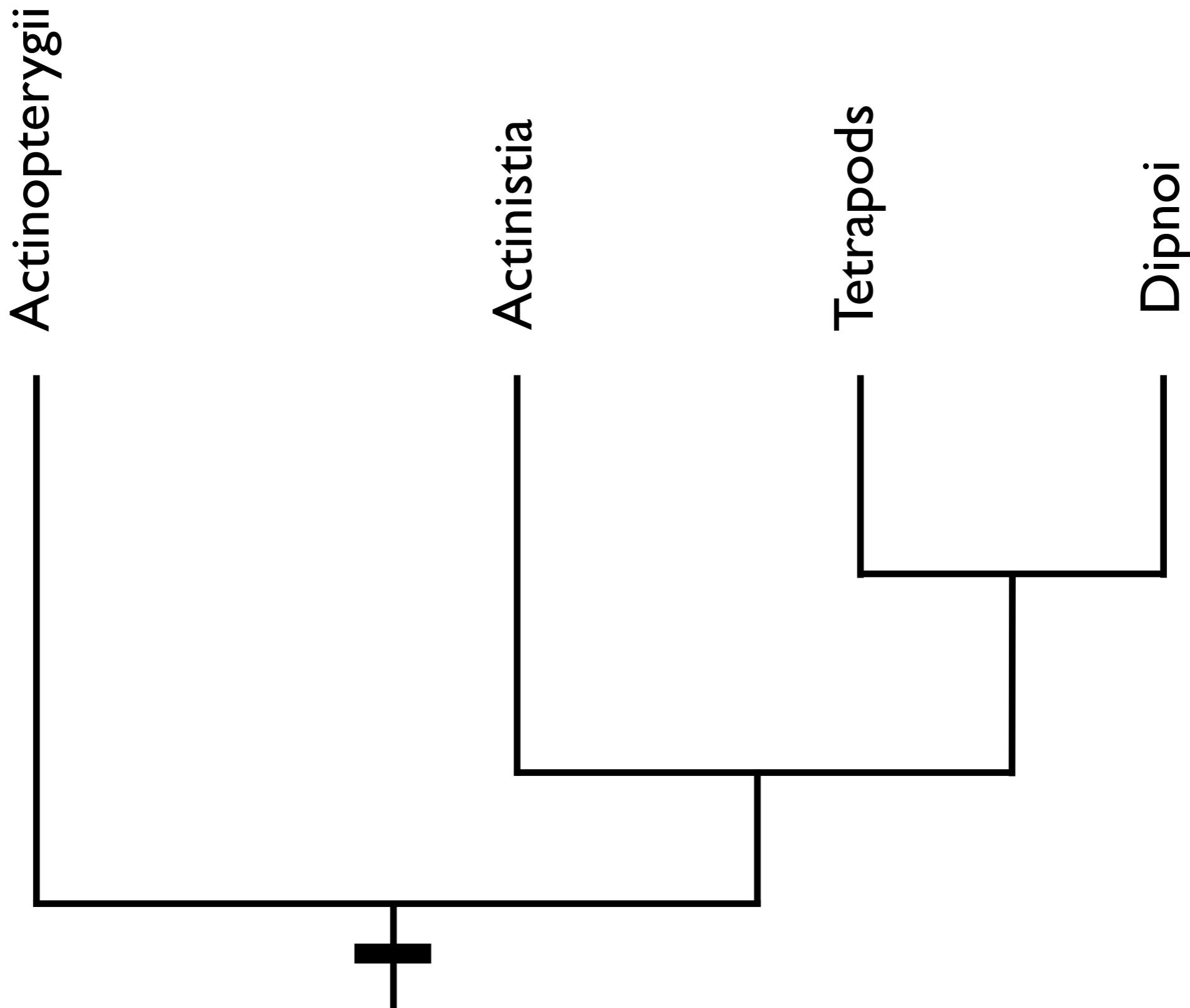
# Actinopterygii



ray-finned fishes

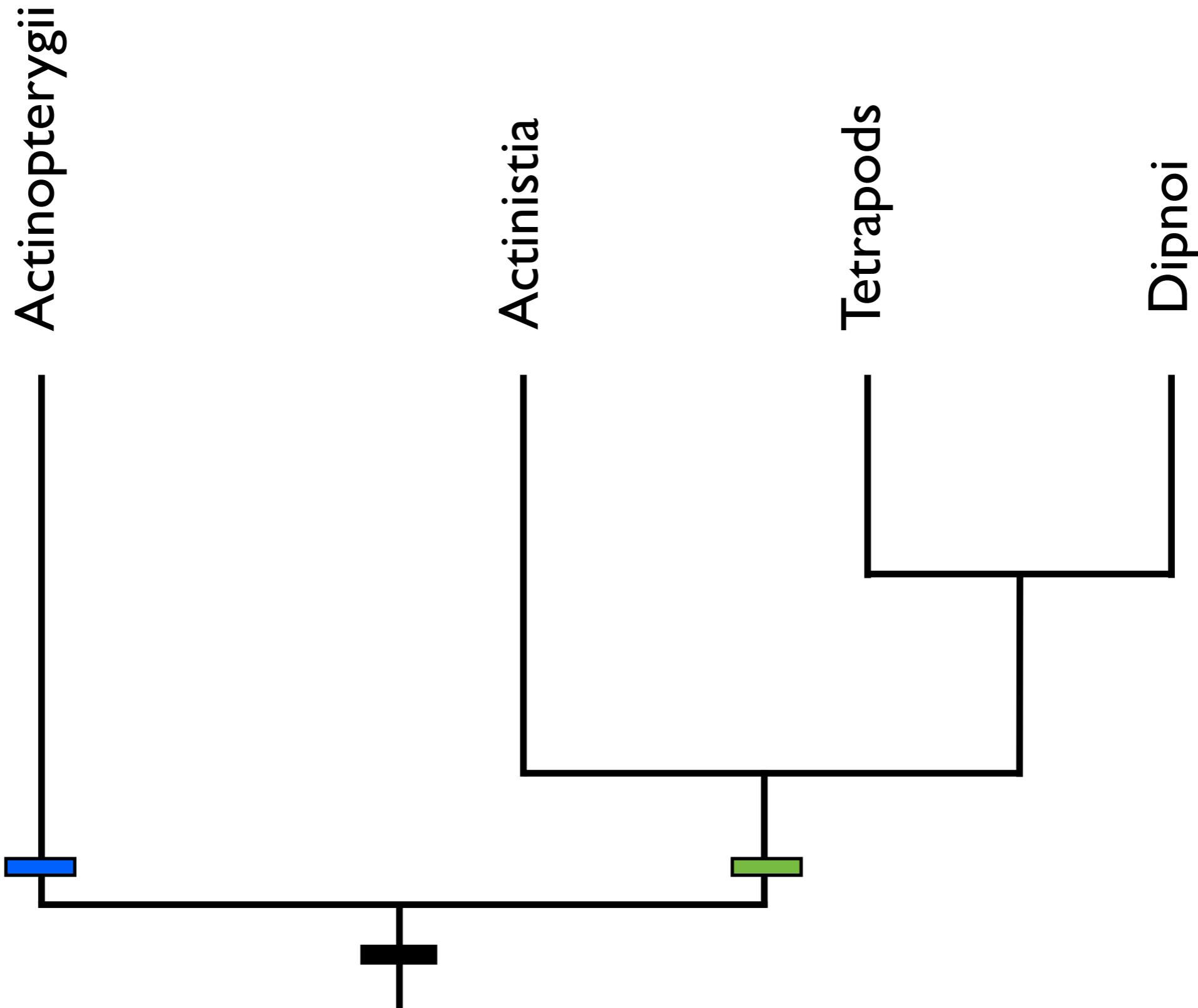


# Osteichthyes (bony fishes)



# Osteichthyes (bony fishes)

= Actinopterygii (ray-finned fishes) + Sarcopterygii (lobe-finned fishes)



Actinistia

92-73007A

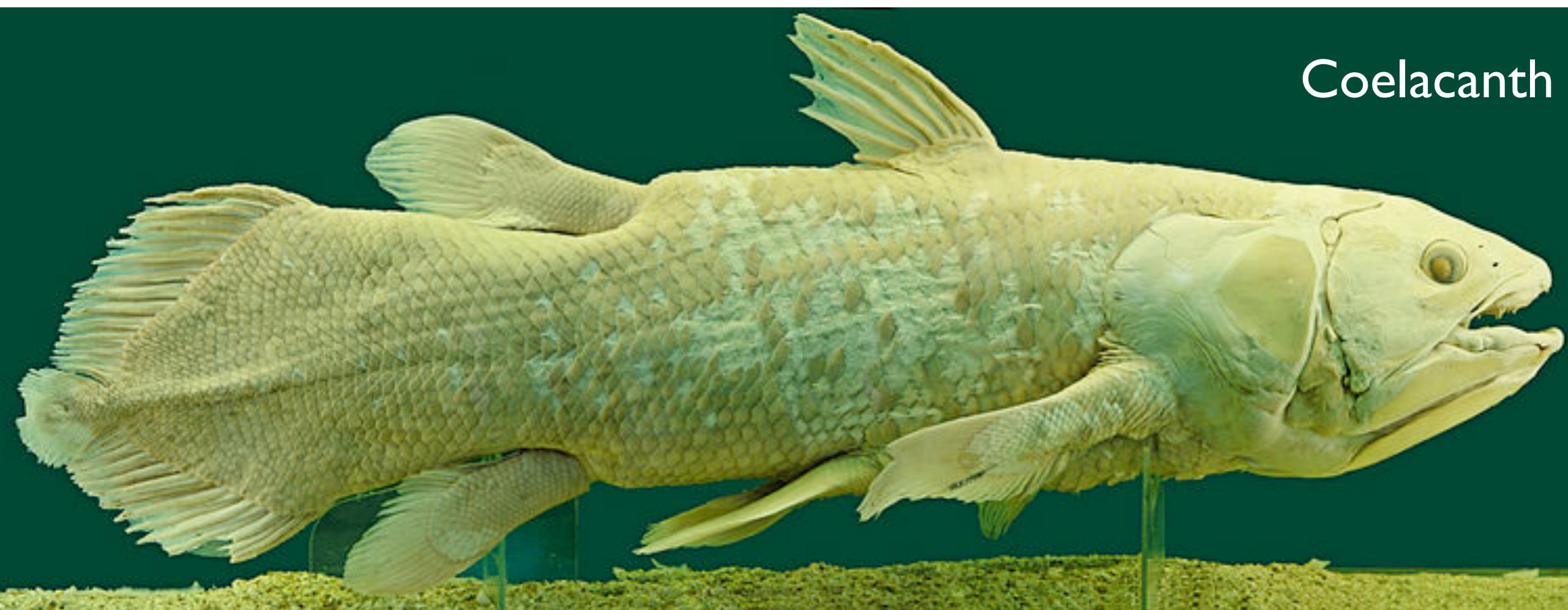


Actinistia

92-73007A



Coelacanth

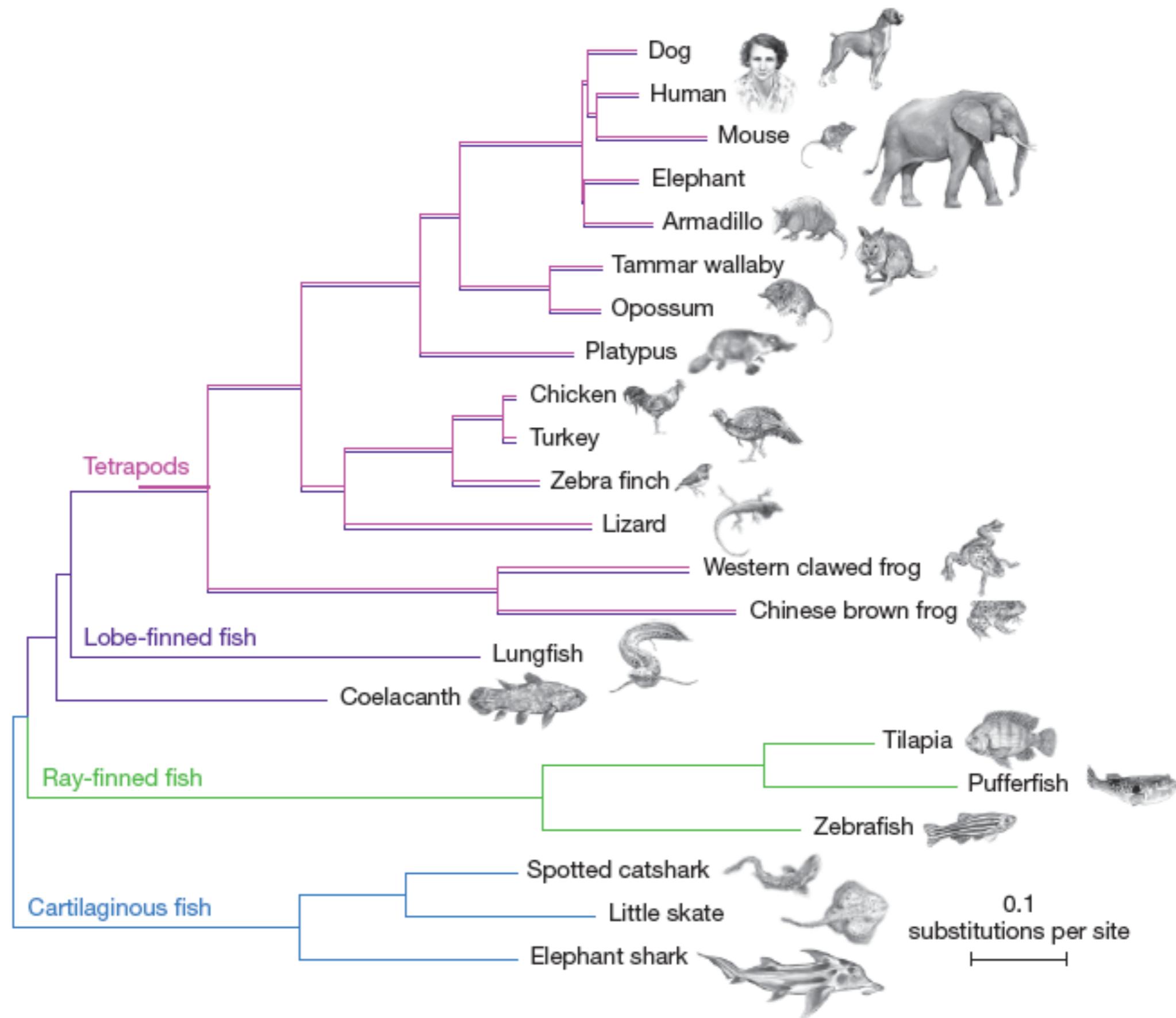




# Dipnoi

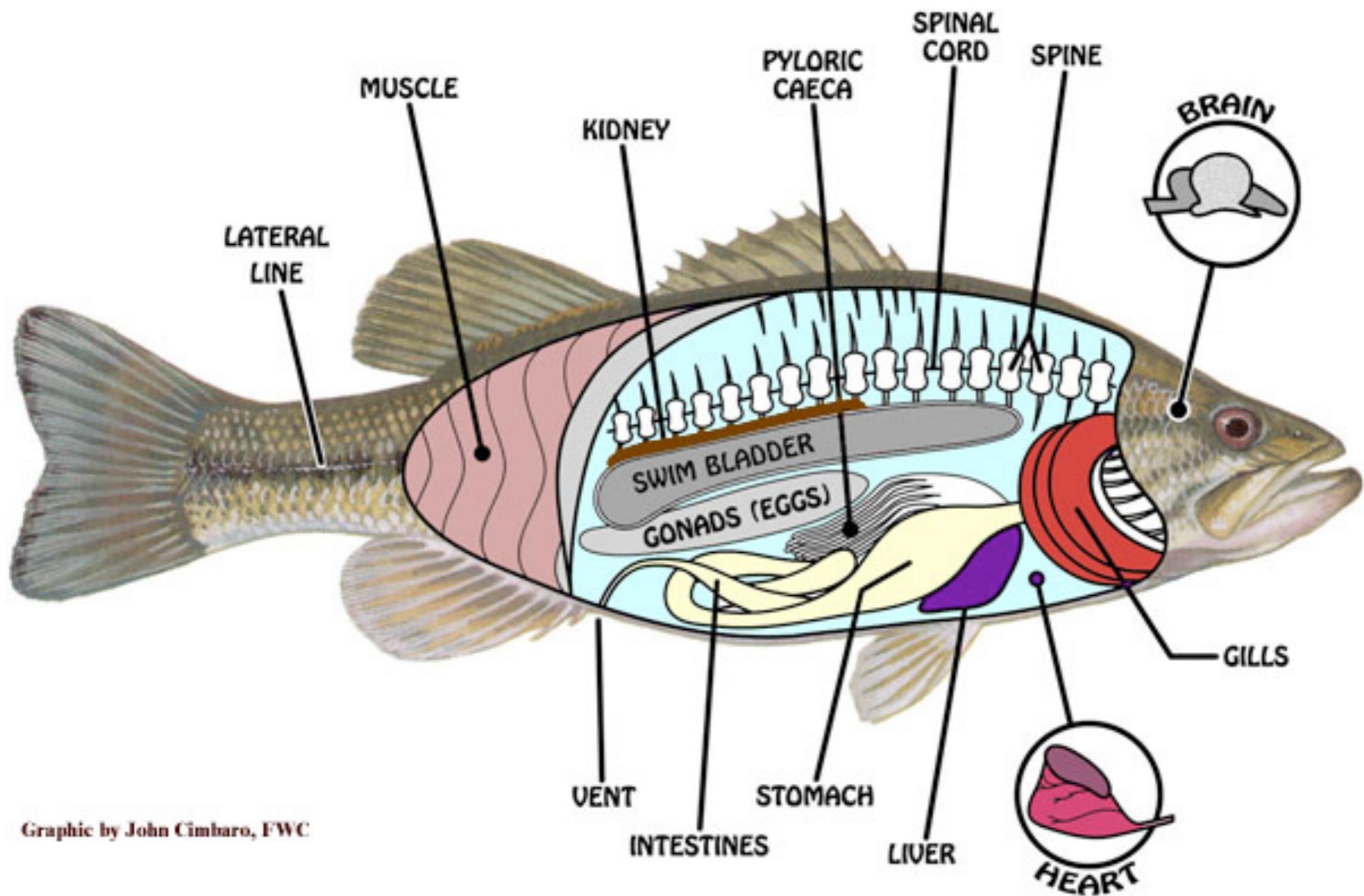


lungfish

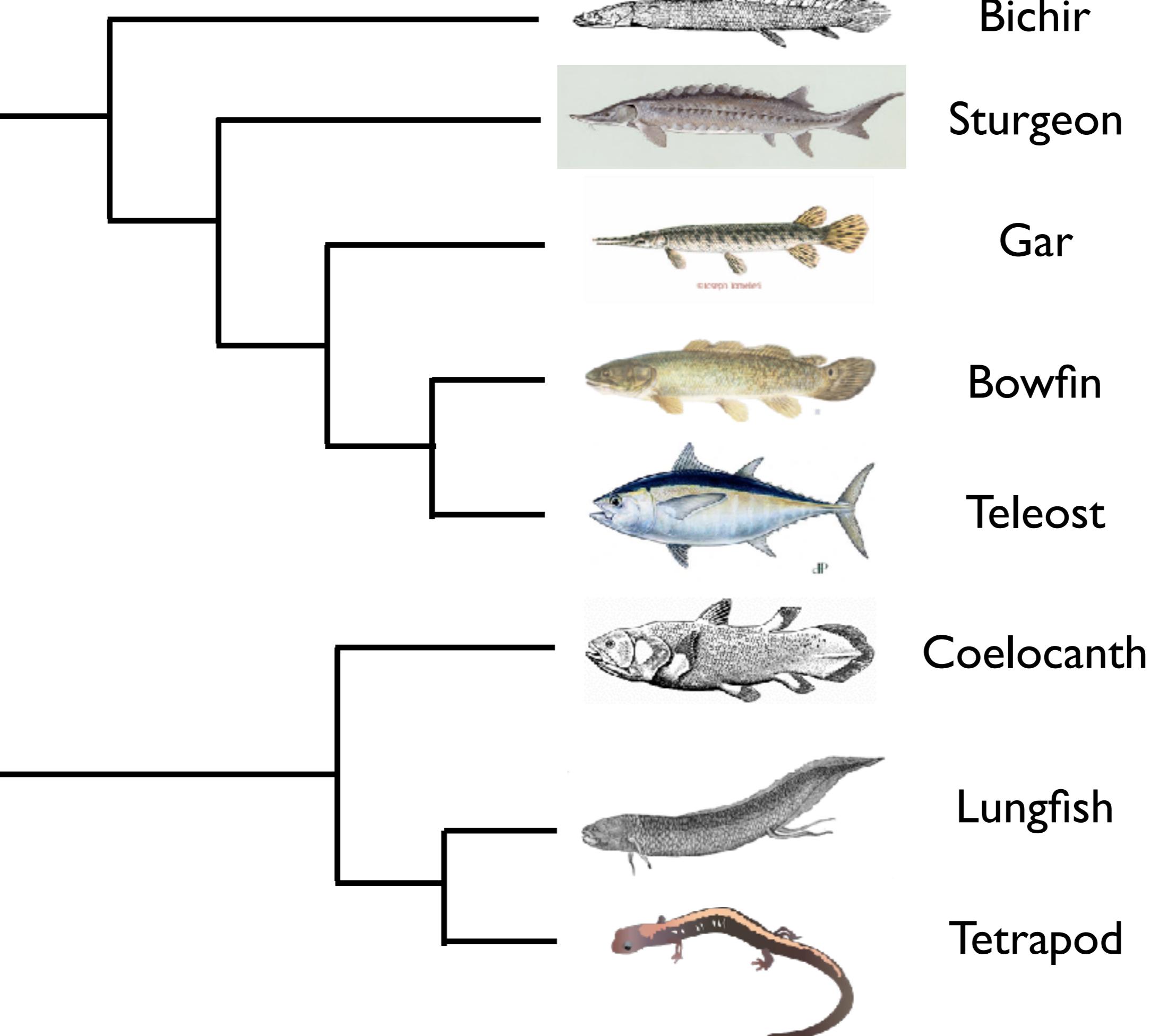


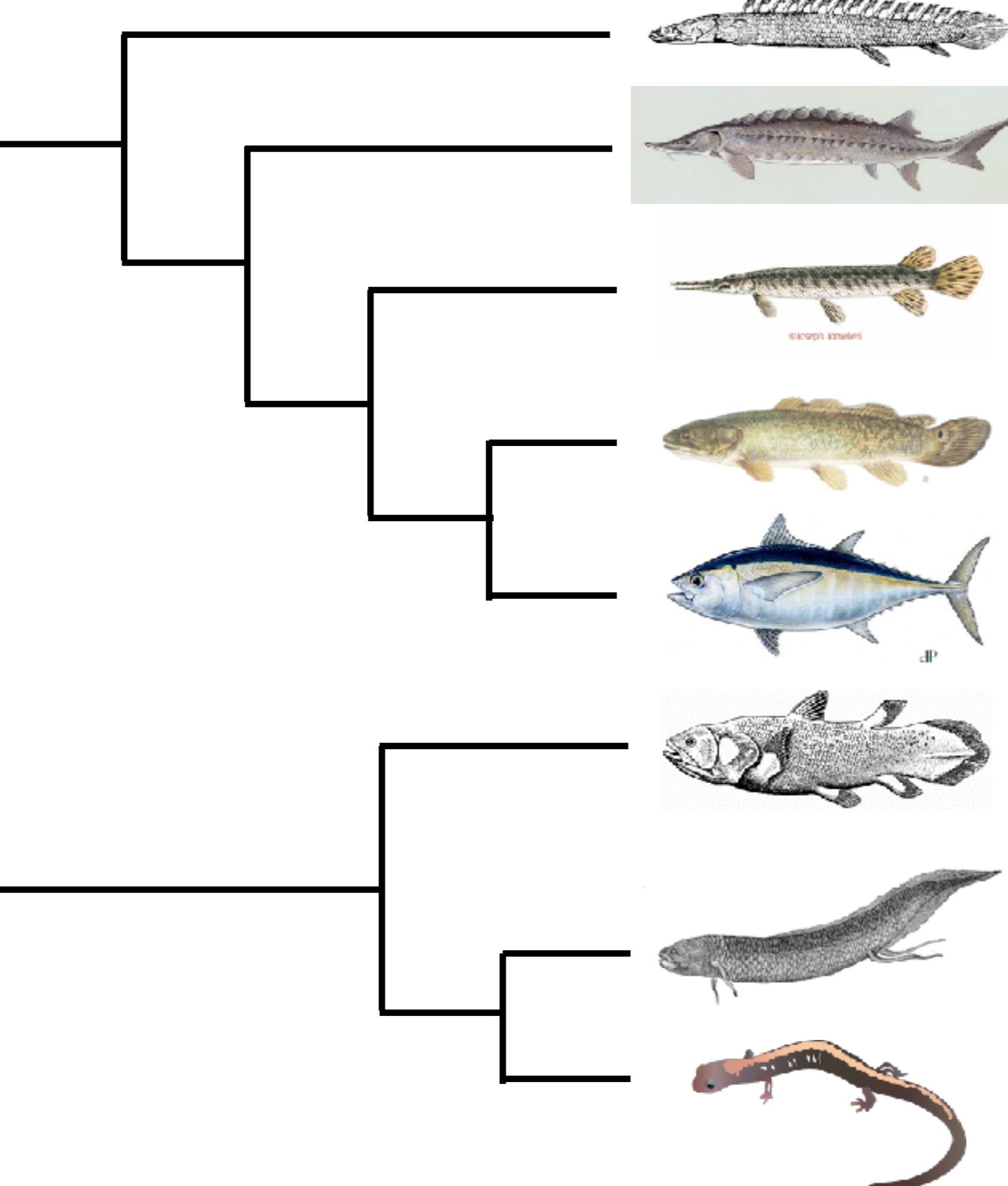
**Figure 1 | A phylogenetic tree of a broad selection of jawed vertebrates shows that lungfish, not coelacanth, is the closest relative of tetrapods.**

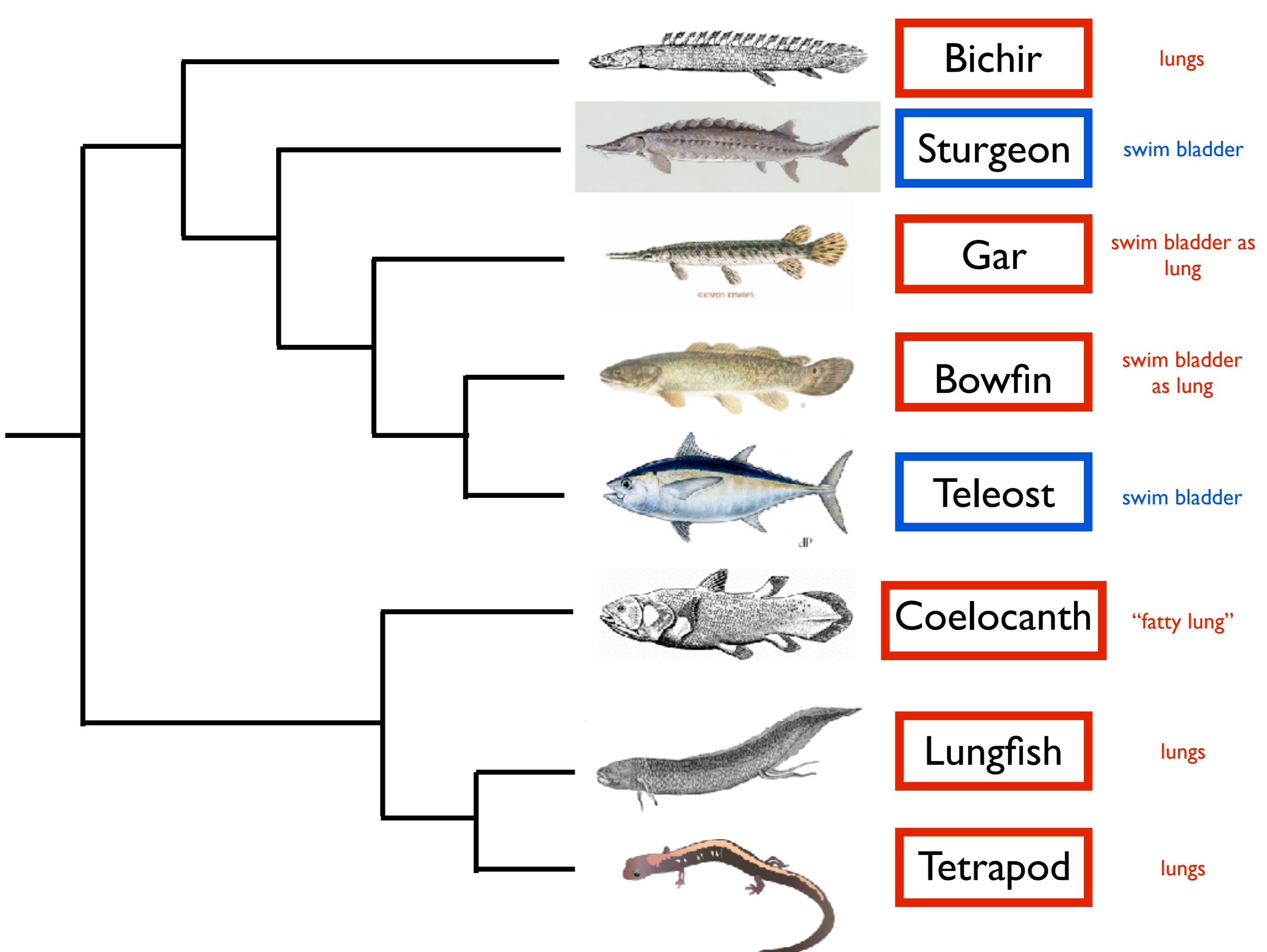


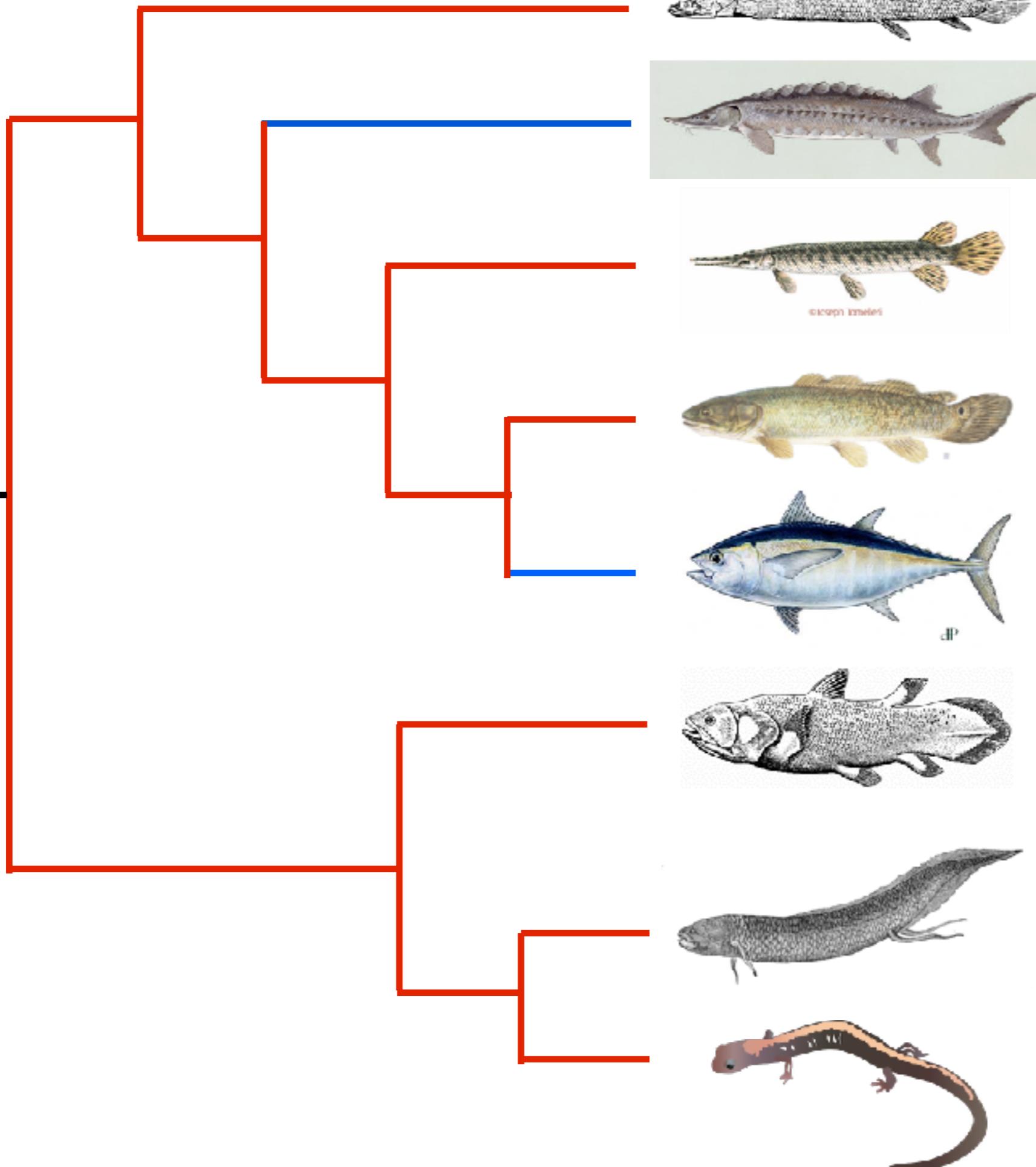


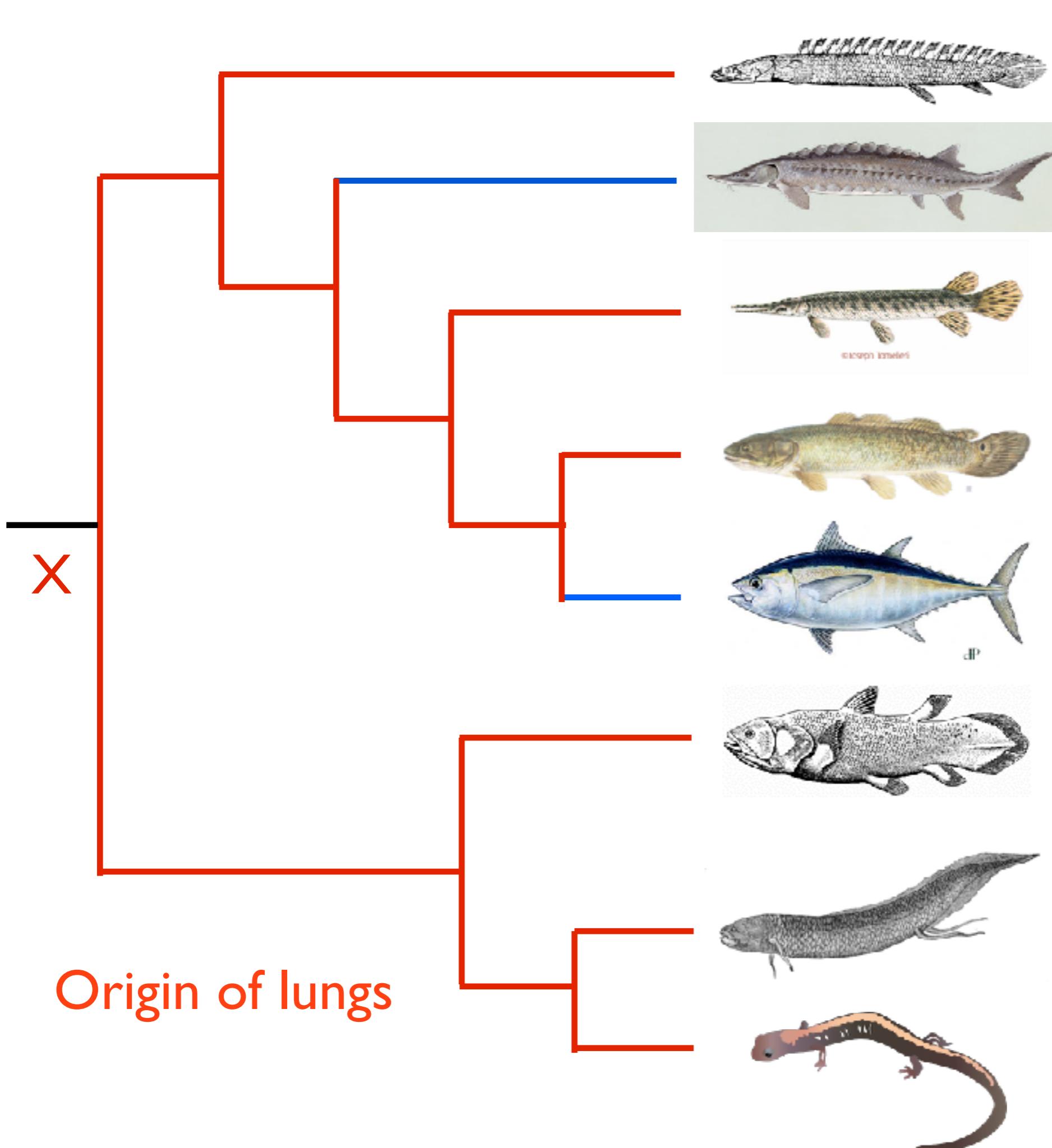
Graphic by John Cimbaro, FWC



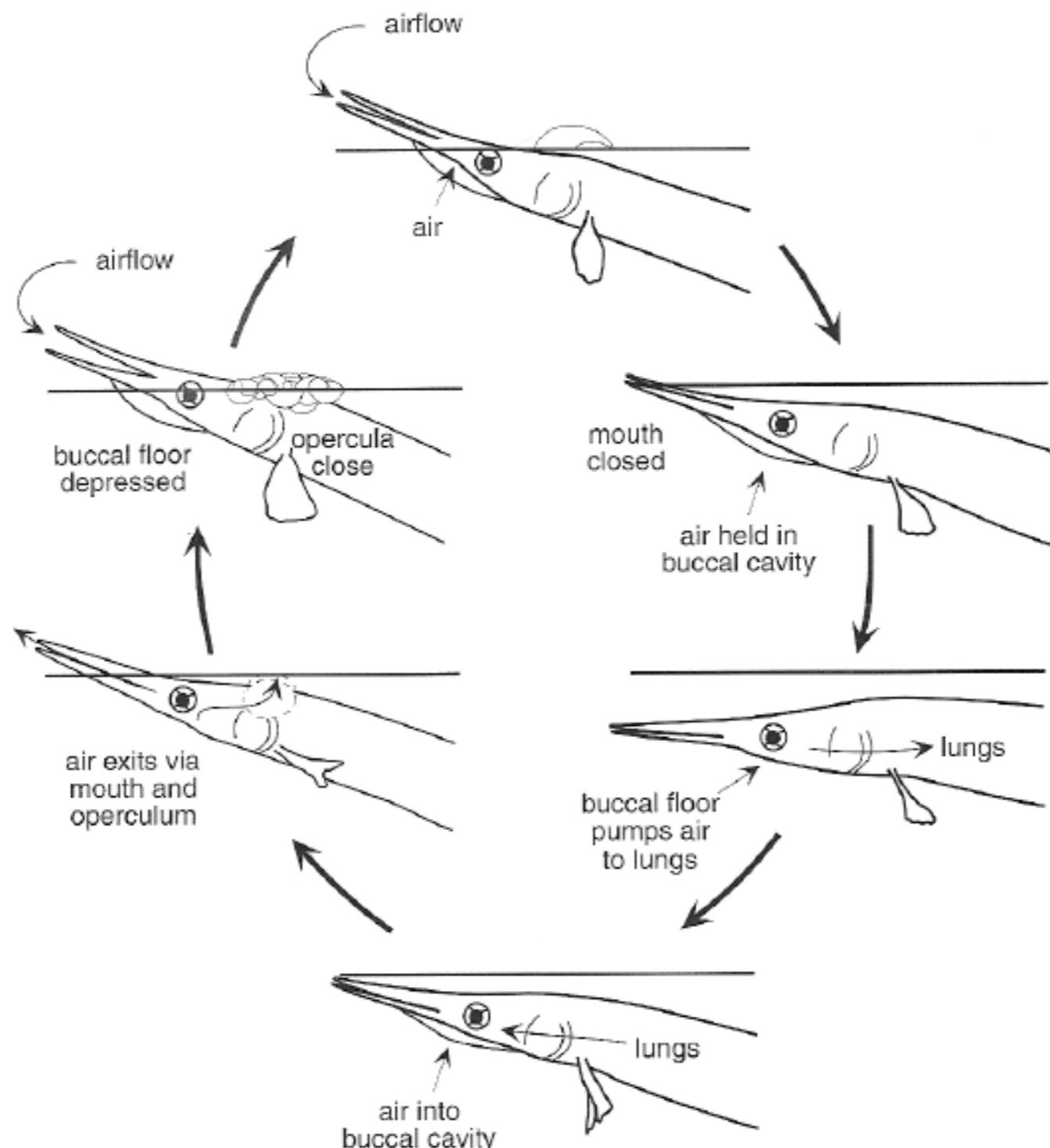








# Lungs in the Water

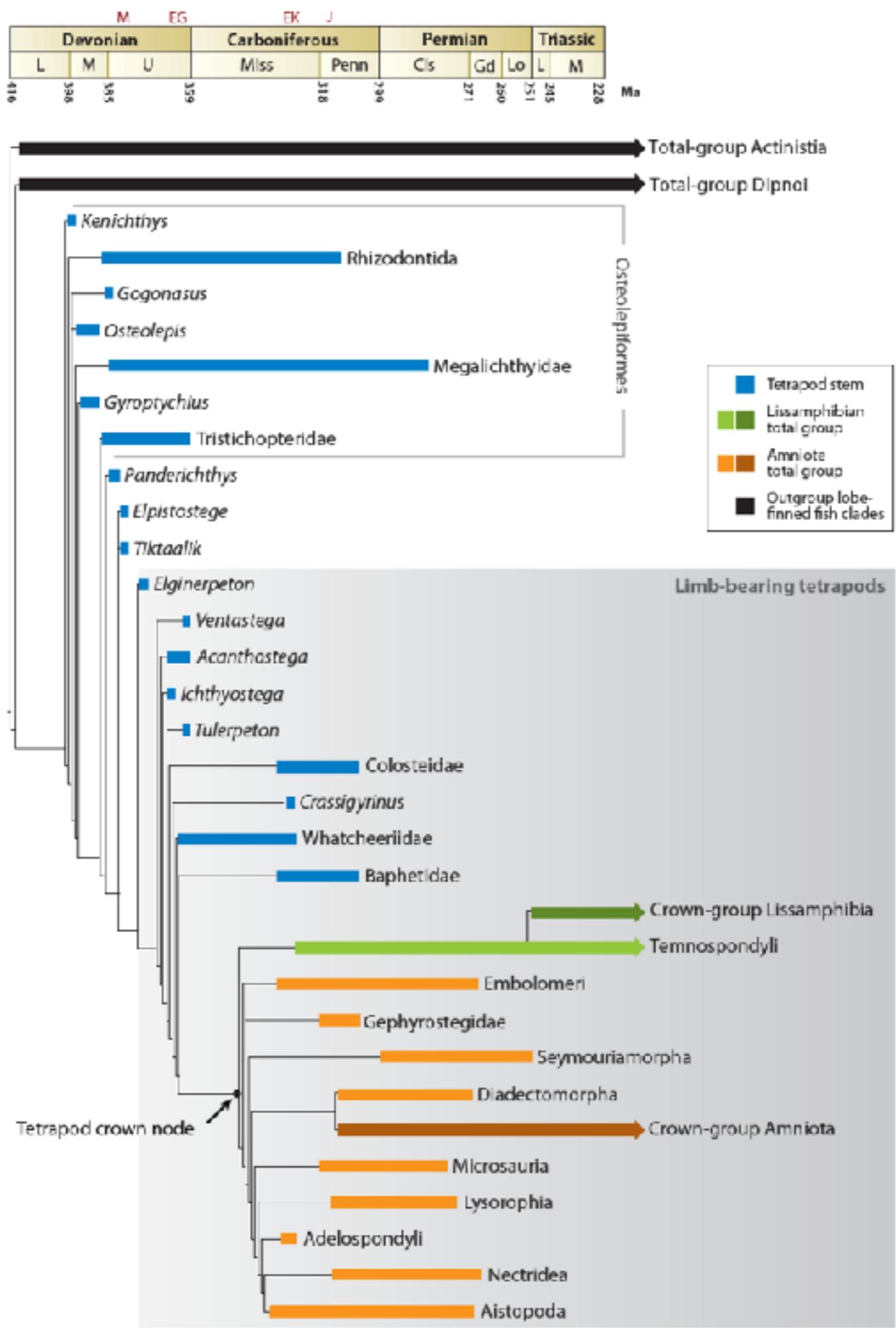


Air breathing cycle in the long-nosed Gar; from Zar et al.

# How do we learn about the origin of herps?

- Study relationships among living species
- Find and analyze fossils
- Understand genetics and development





# *Tiktaalik*



*Tiktaalik* could paddle & do push-ups...

**Fin as a Paddle**



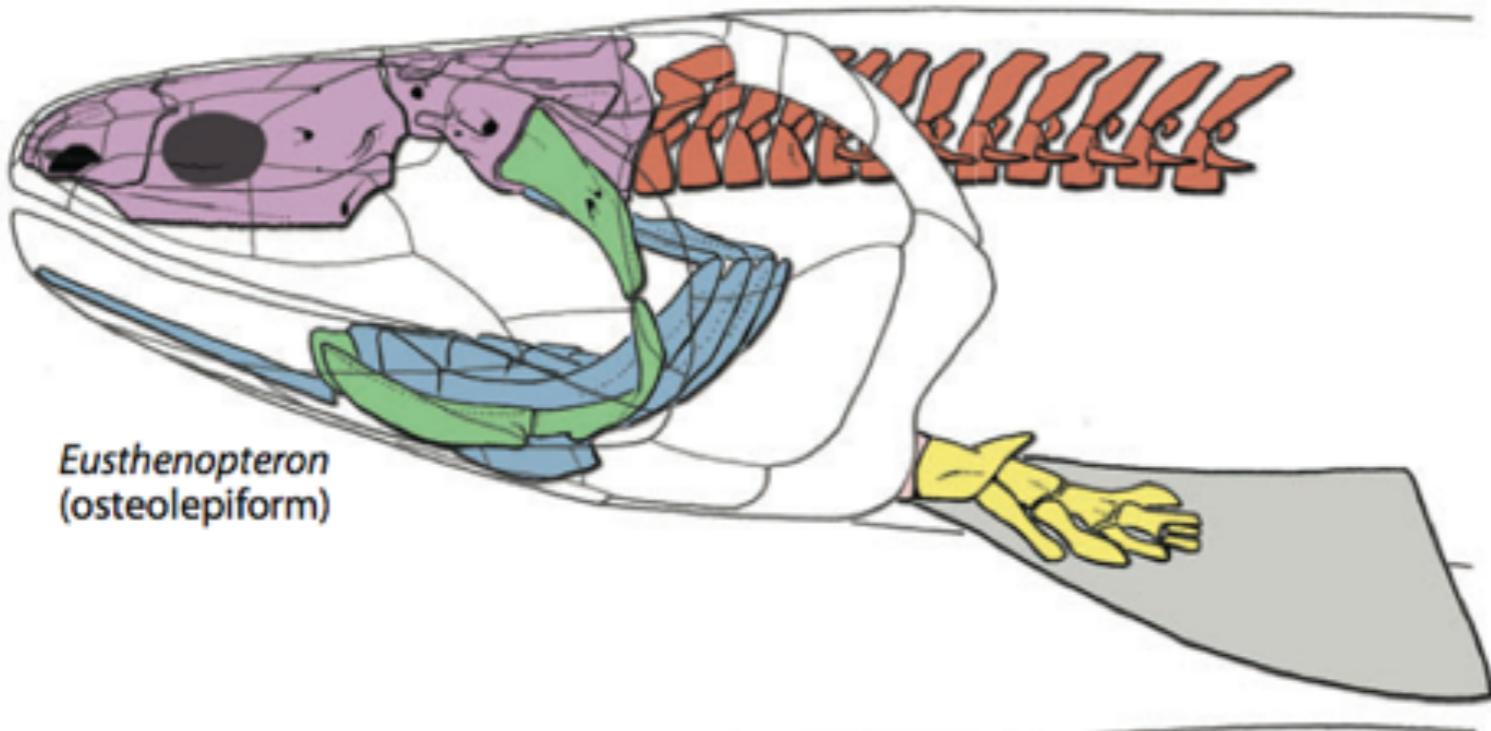
**Fin as a Prop**



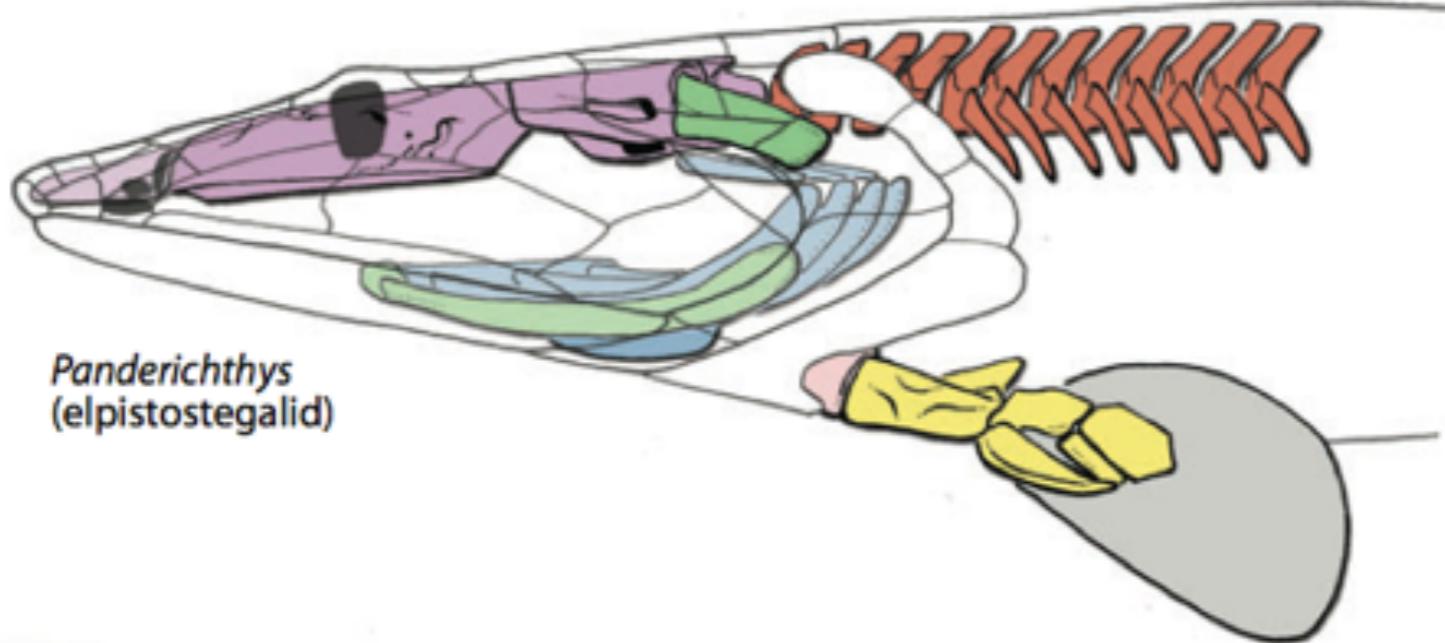
# *Ichthyostega*



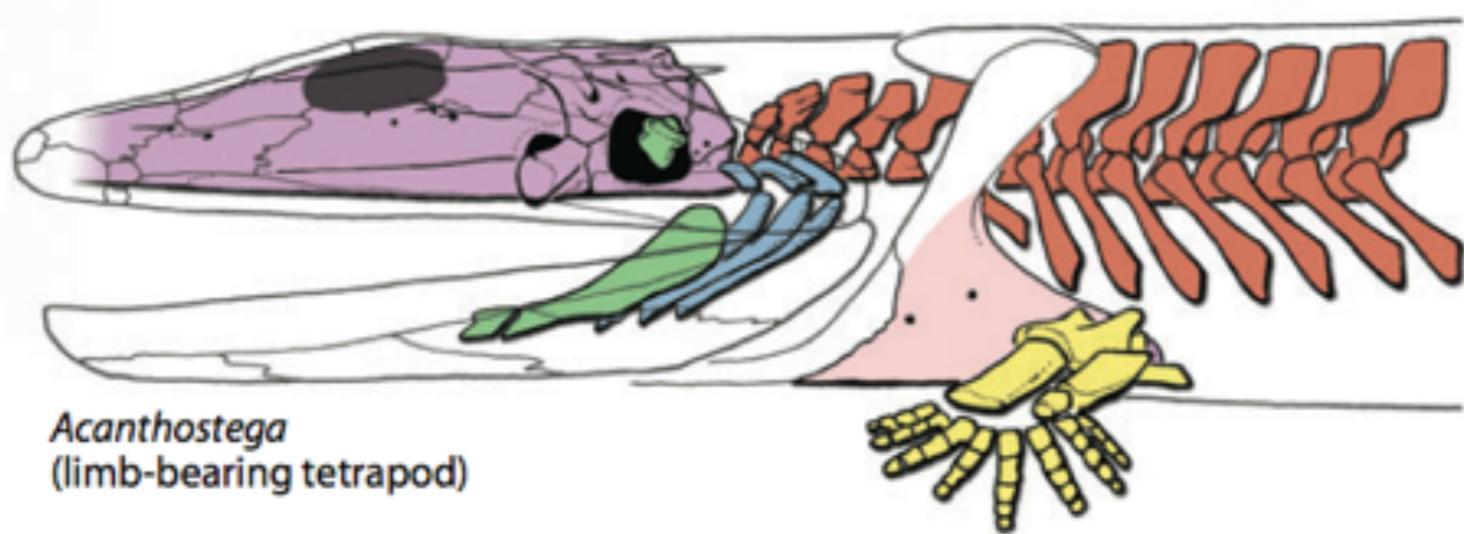
- 365 mya
- Limbs with 7 digits
- Fish-like tail but likely some ability to move on land



*Eusthenopteron*  
(osteolepiform)



*Panderichthys*  
(elpistostegid)



*Acanthostega*  
(limb-bearing tetrapod)

- Braincase
- Hyoid arch
- Gill arches
- Vertebral column
- Primary (endoskeletal) pectoral girdle
- Primary (endoskeletal) pectoral fin/ forelimb
- Finweb (dermal skeletal)

**All of these organisms had limbs but were aquatic!**

# Things you might think about the transition to land

**Legs** evolved for locomotion on land

**Lungs** evolved for breathing on land

# Things you might think about the transition to land

~~-Legs evolved for locomotion on land-~~

Lungs evolved for breathing on land

# Things you might think about the transition to land

~~-Legs evolved for locomotion on land-~~

~~-Lungs evolved for breathing on land-~~

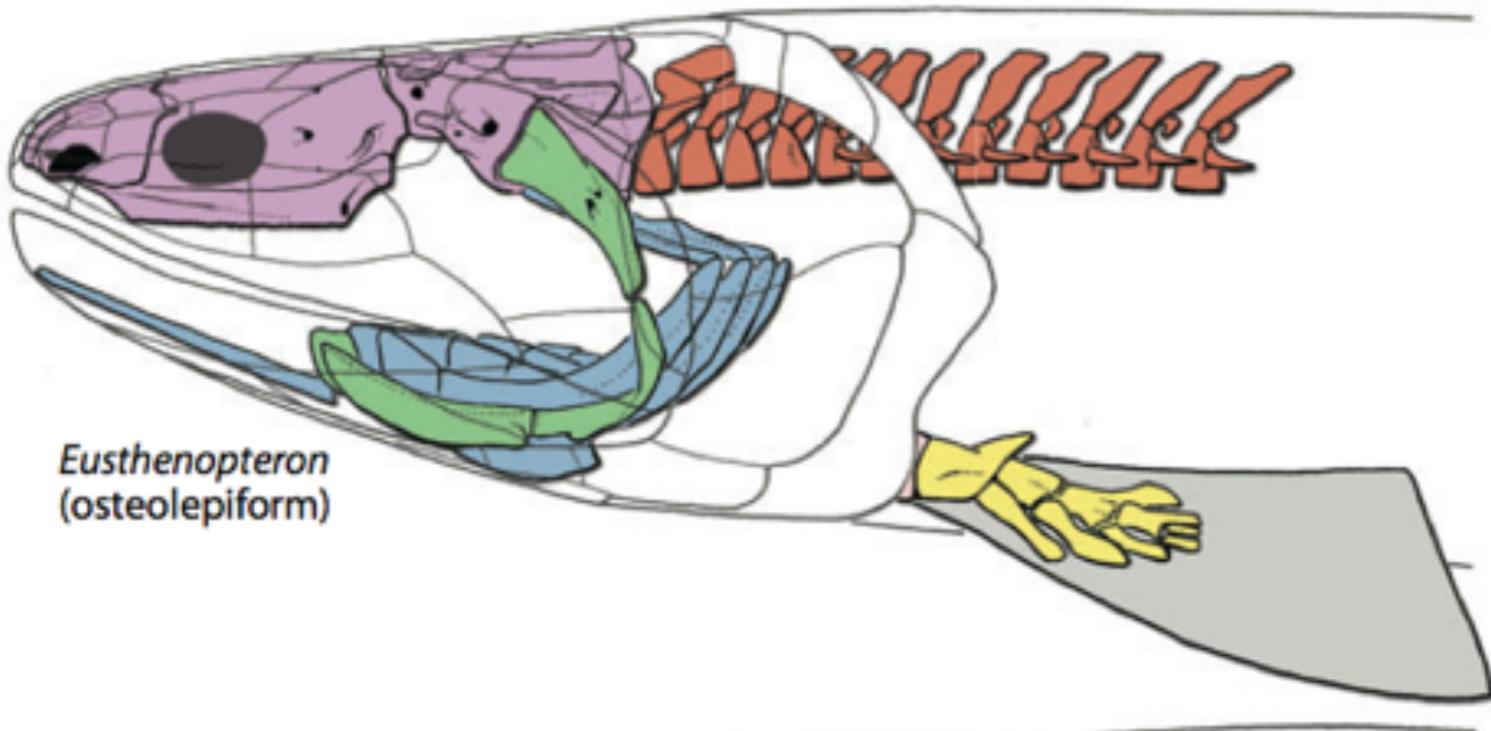
# Updated Story

- Many features of tetrapods first evolved in an aquatic habitat
- These features turned out to be quite useful when the transition to land occurred
- **Exaptation:** a trait that evolved for one function that is co-opted by selection to serve another function

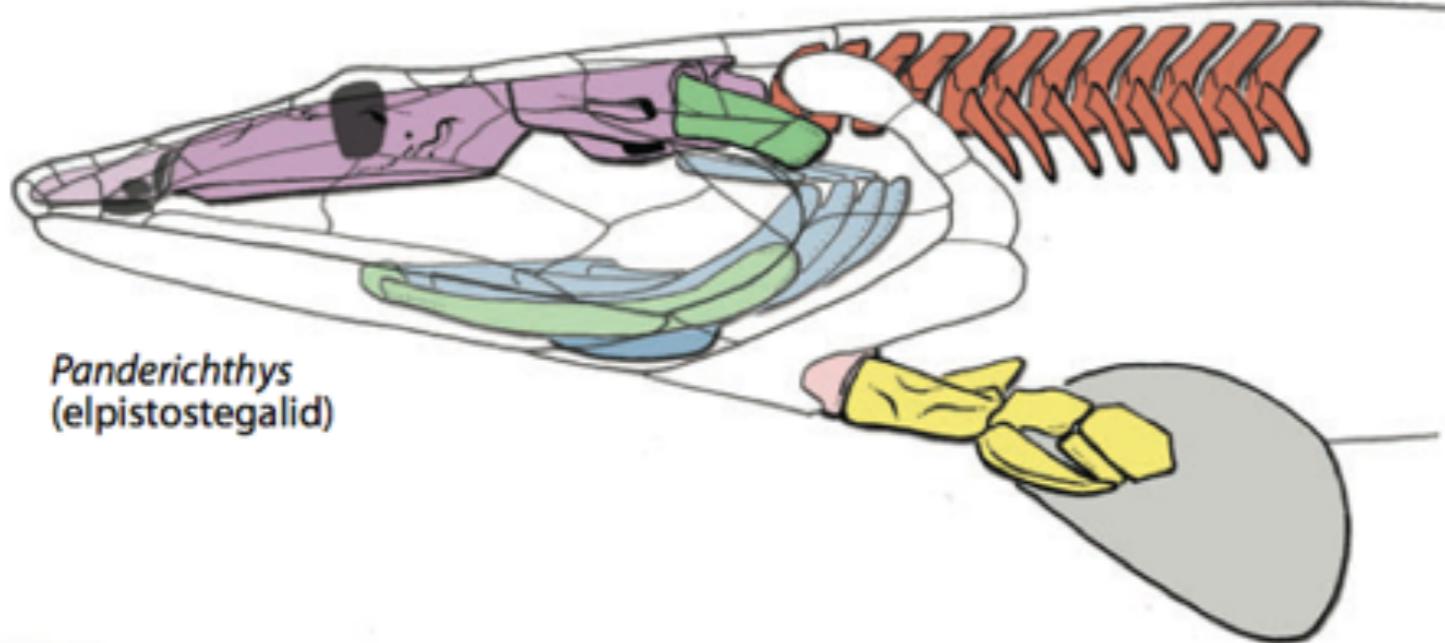
**Ancestry matters!**

# How do we learn about the origin of herps?

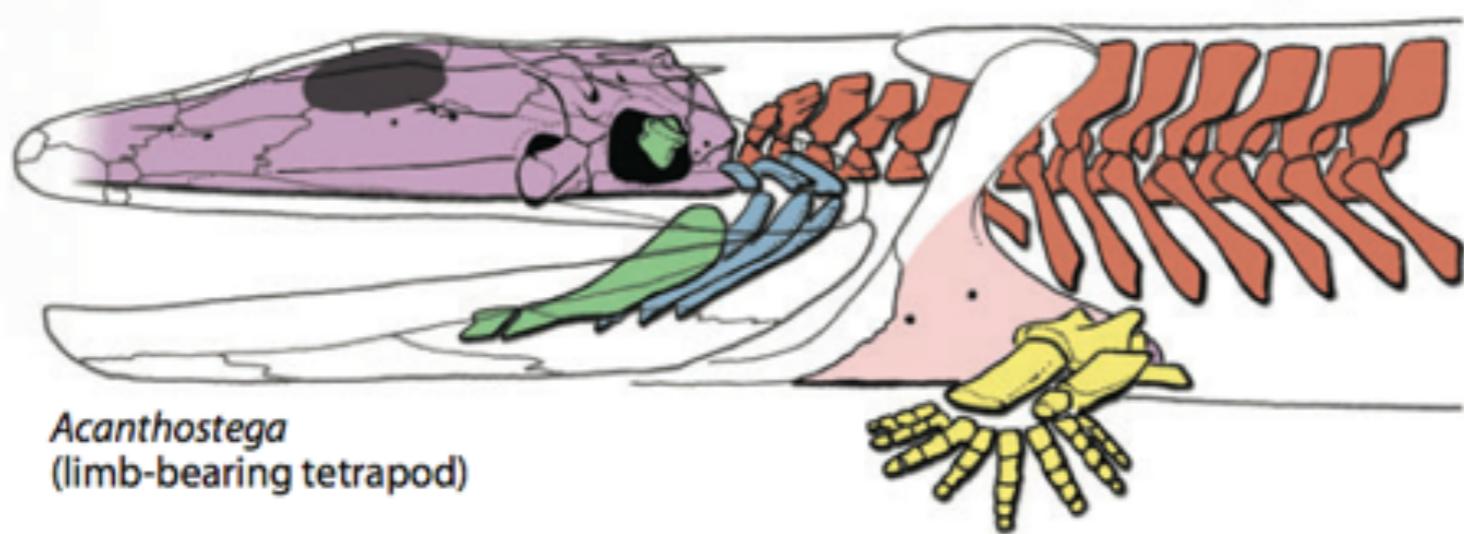
- Study relationships among living species
- Find and analyze fossils
- Understand genetics and development



*Eusthenopteron*  
(osteolepiform)



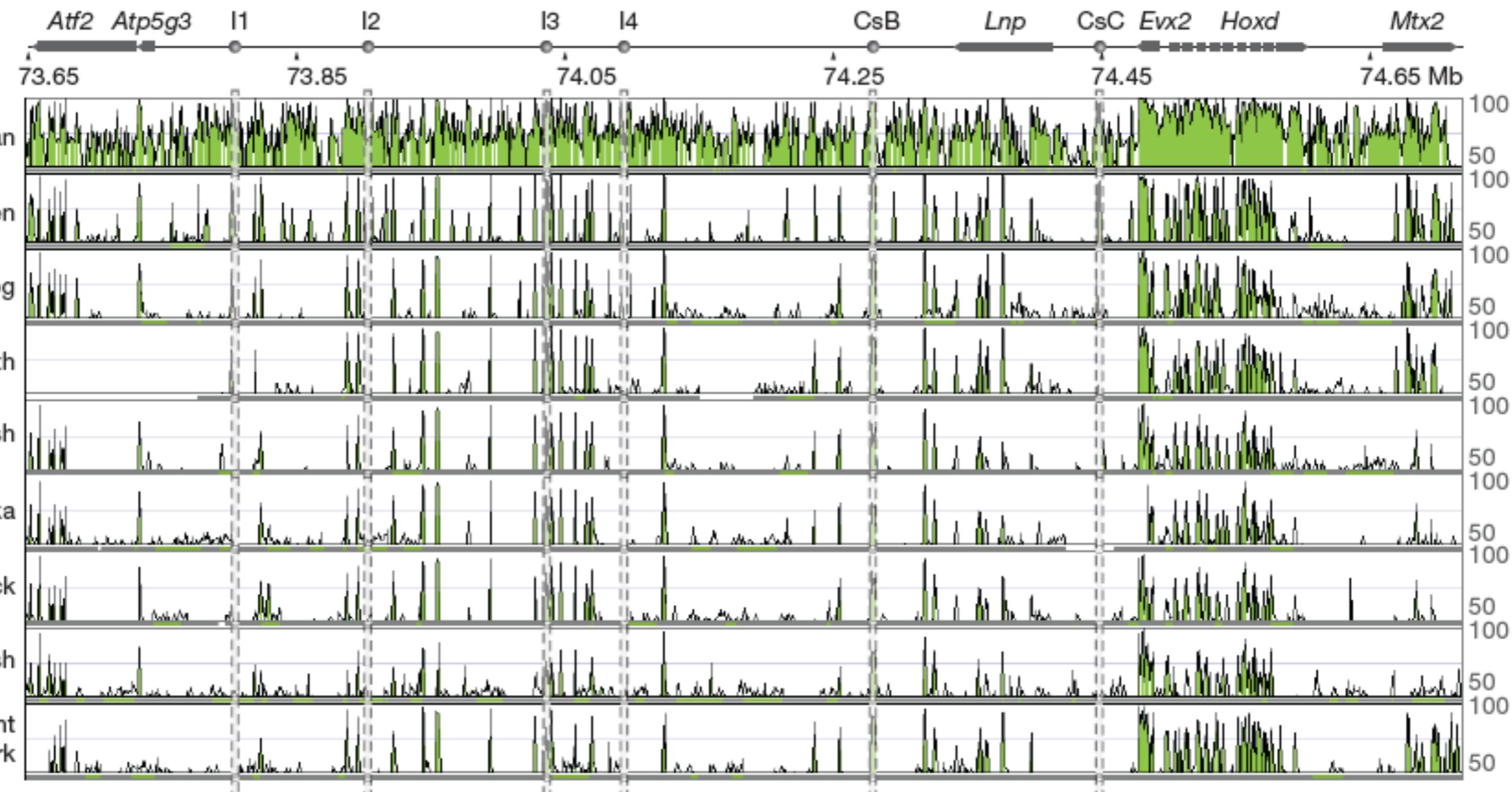
*Panderichthys*  
(elpistostegid)

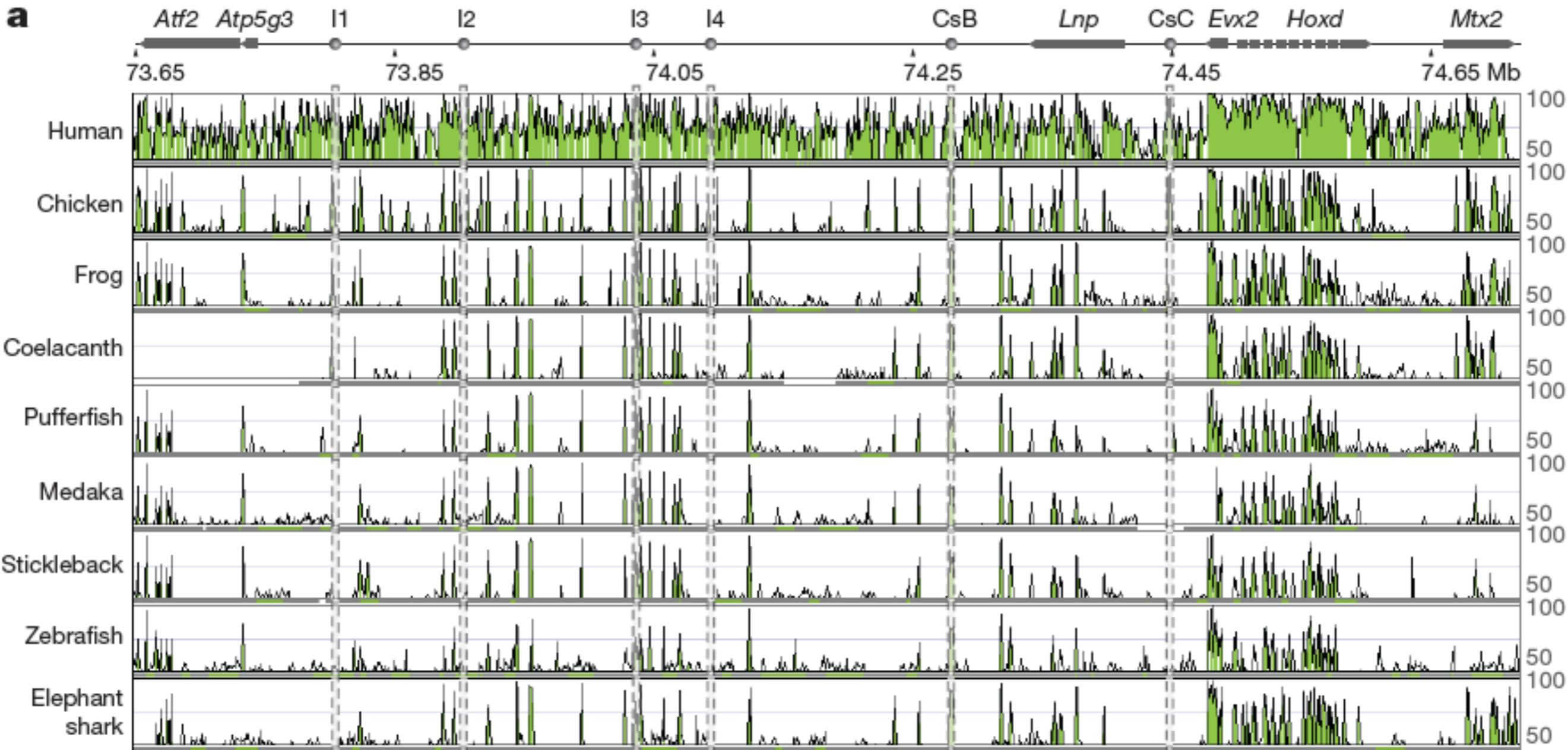
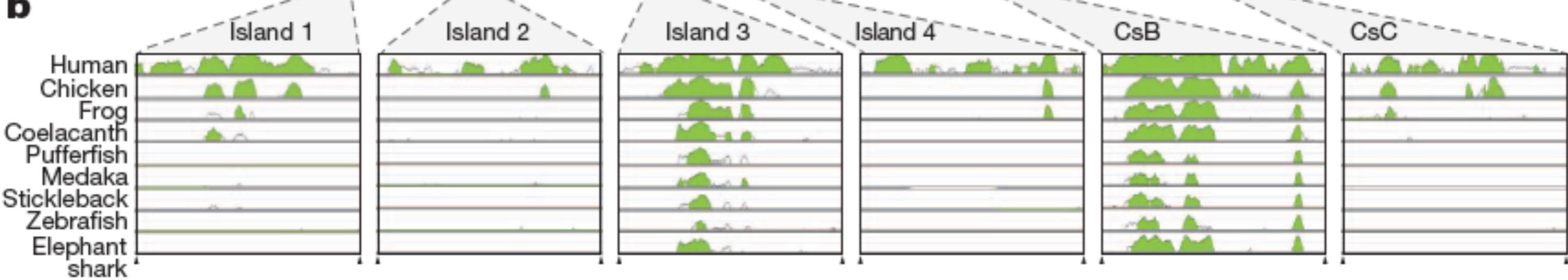


*Acanthostega*  
(limb-bearing tetrapod)

- Braincase
- Hyoid arch
- Gill arches
- Vertebral column
- Primary (endoskeletal) pectoral girdle
- Primary (endoskeletal) pectoral fin/ forelimb
- Finweb (dermal skeletal)

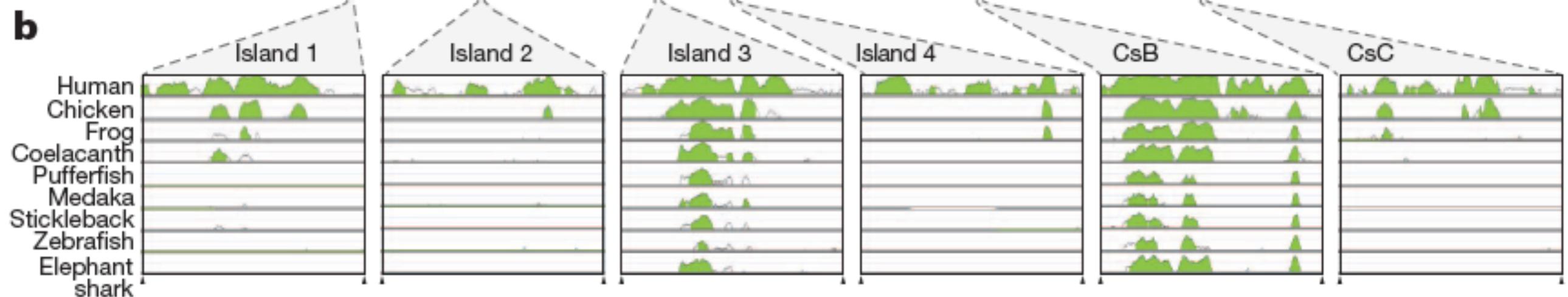
a

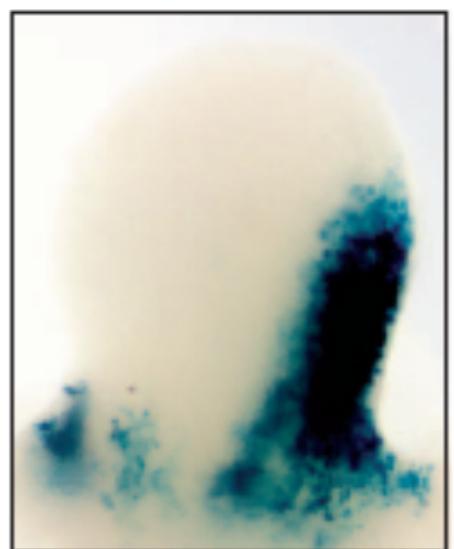
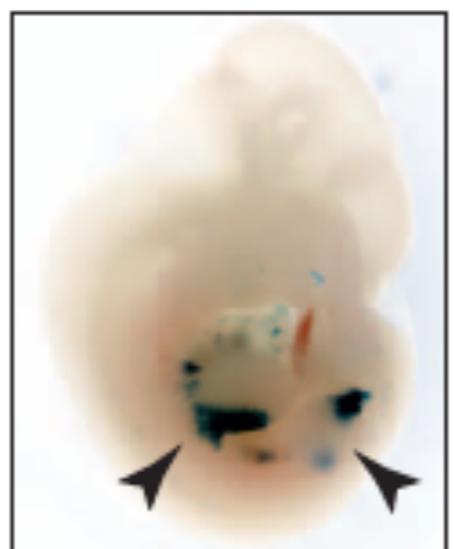
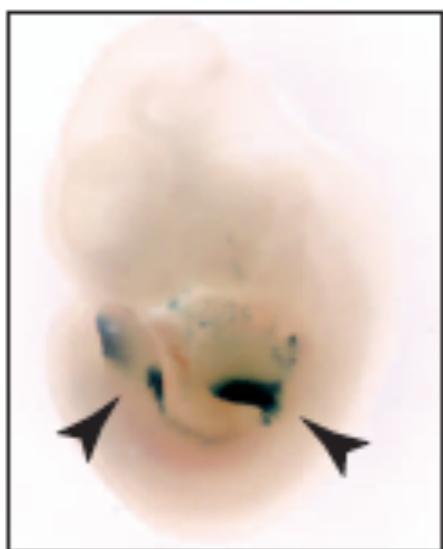


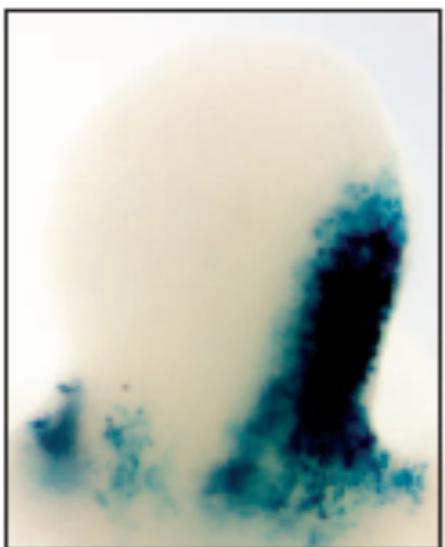
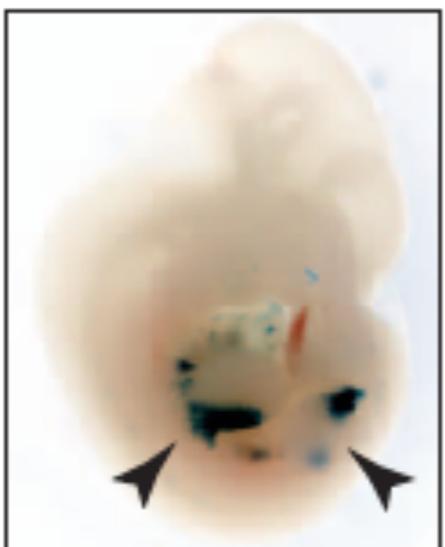
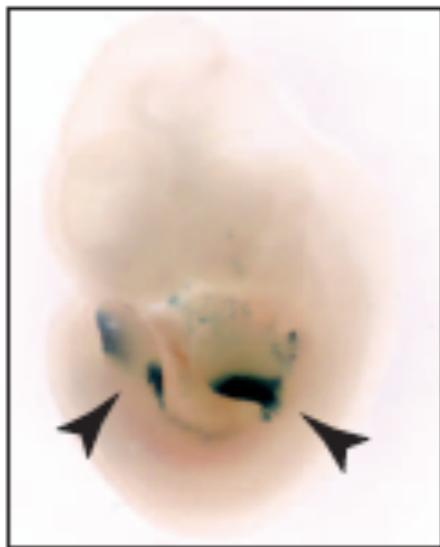
**a****b**



**b**



**C**

**C**

Coelocanth and tetrapods share a HOX-D regulatory element that is associated with limb-bud development

This HOX-D element is very likely a key genetic change associated with the early origins of tetrapods

# Science

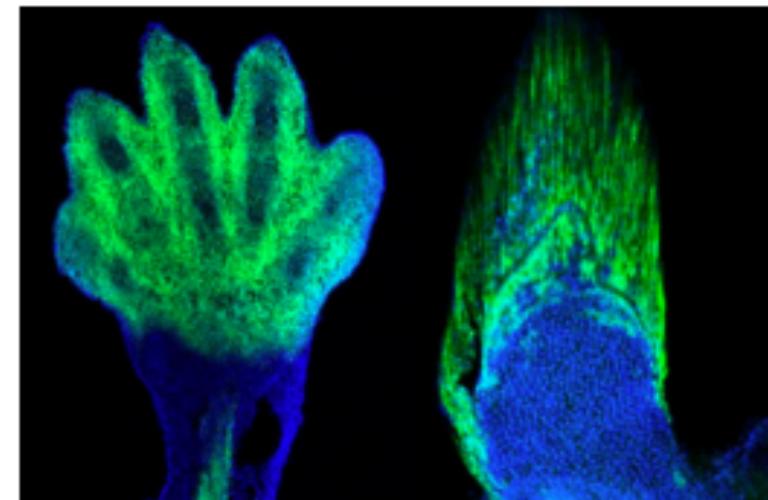
ENVIRONMENT | SPACE & COSMOS | HEALTH | TRILOBITES | SCIENCETAKE | OUT THERE



CRAIG COOK/UNDERSEA MEDICAL

**Giant Coral Reef in Protected Area Shows New Signs of**

1:12



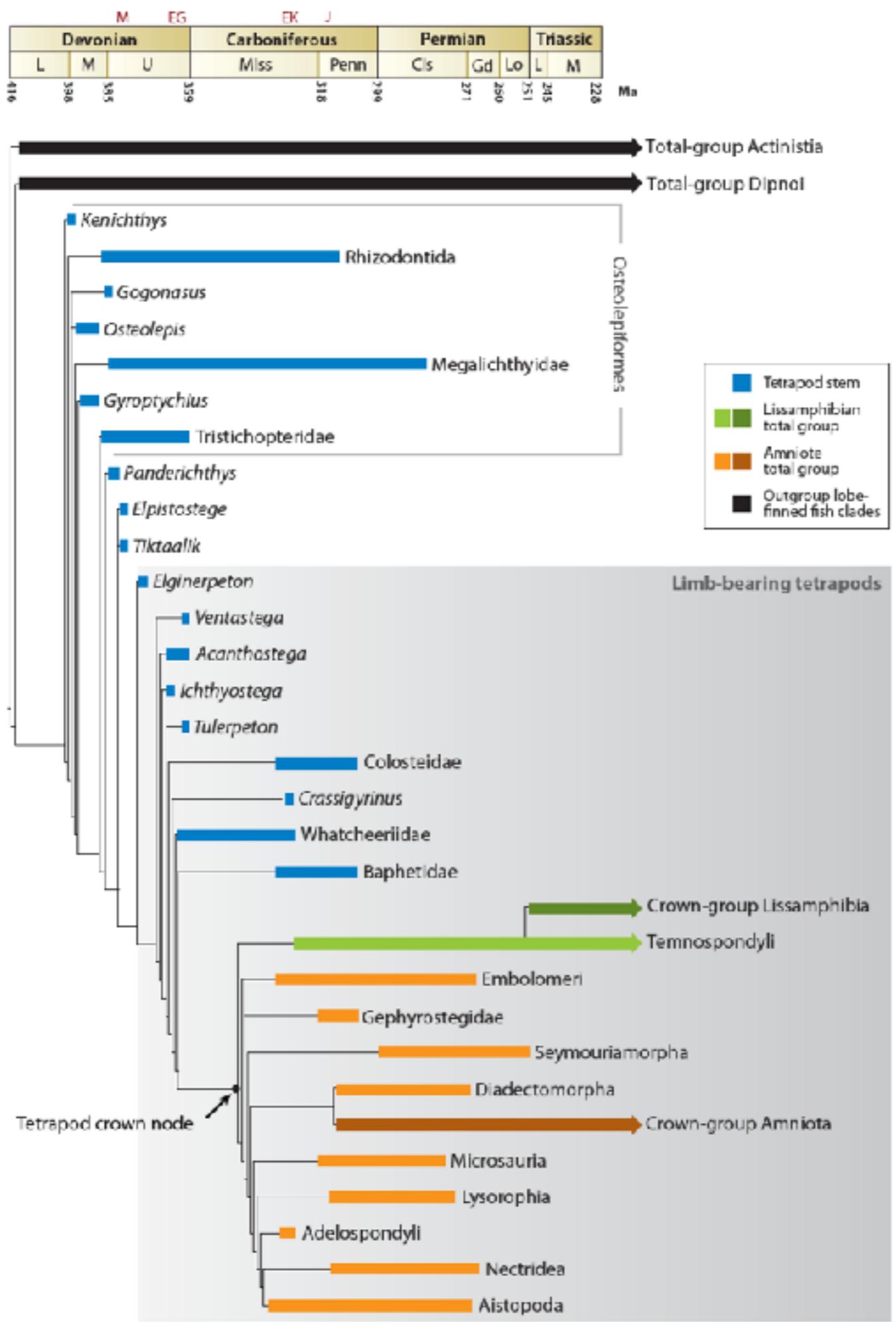
MARIE KMITA AND ANDREW GEHRKE

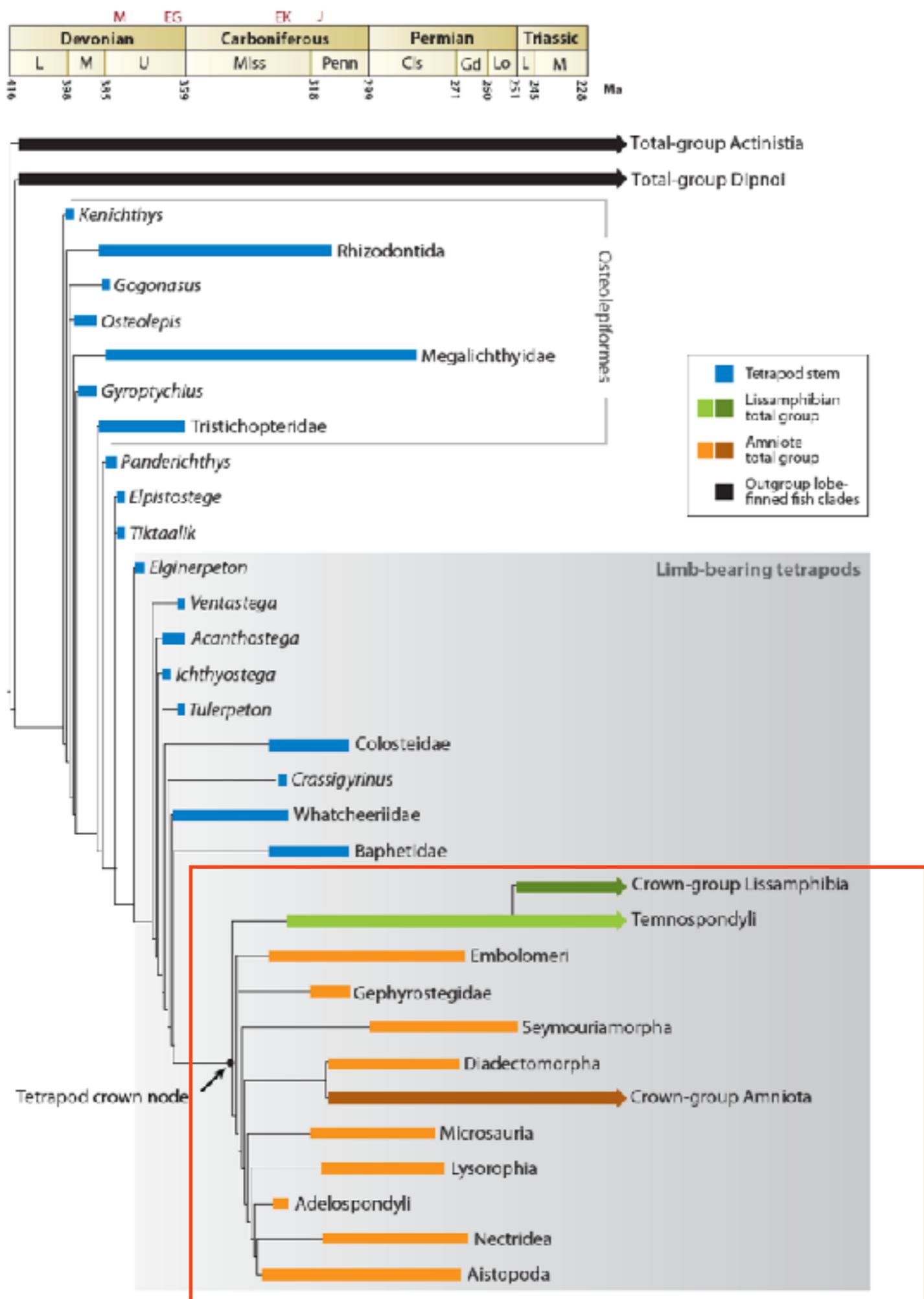
MATTER

## From Fins Into Hands: Scientists Discover a Deep Evolutionary Link

The findings by a University of Chicago team will help researchers understand how our ancestors left the water, transforming fins into limbs so they could move on land.

1d ago · By CARL ZIMMER





Crown-group tetrapods illustrate the rapid divergence  
of today's major tetrapod groups:

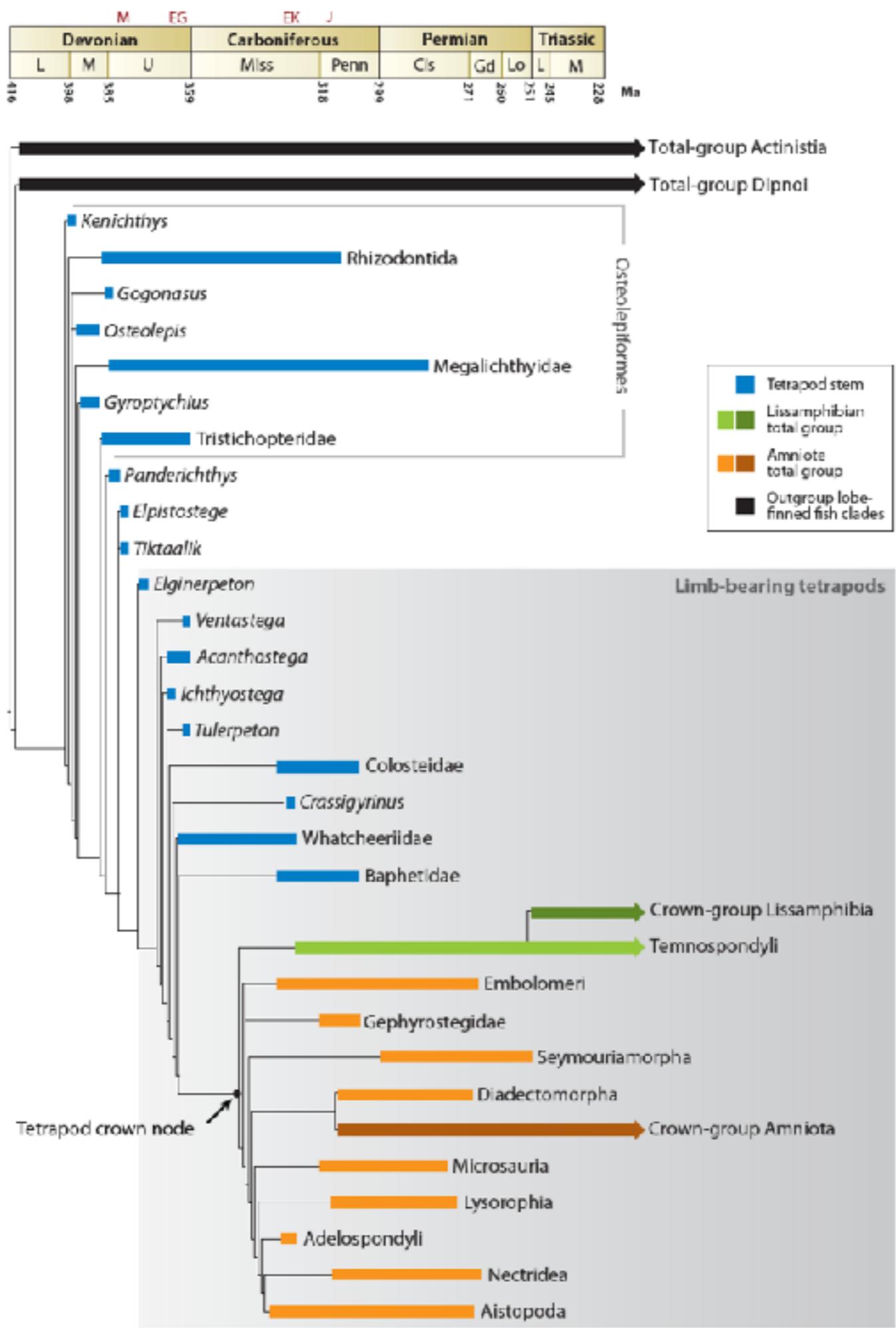
Crown-group tetrapods illustrate the rapid divergence  
of today's major tetrapod groups:

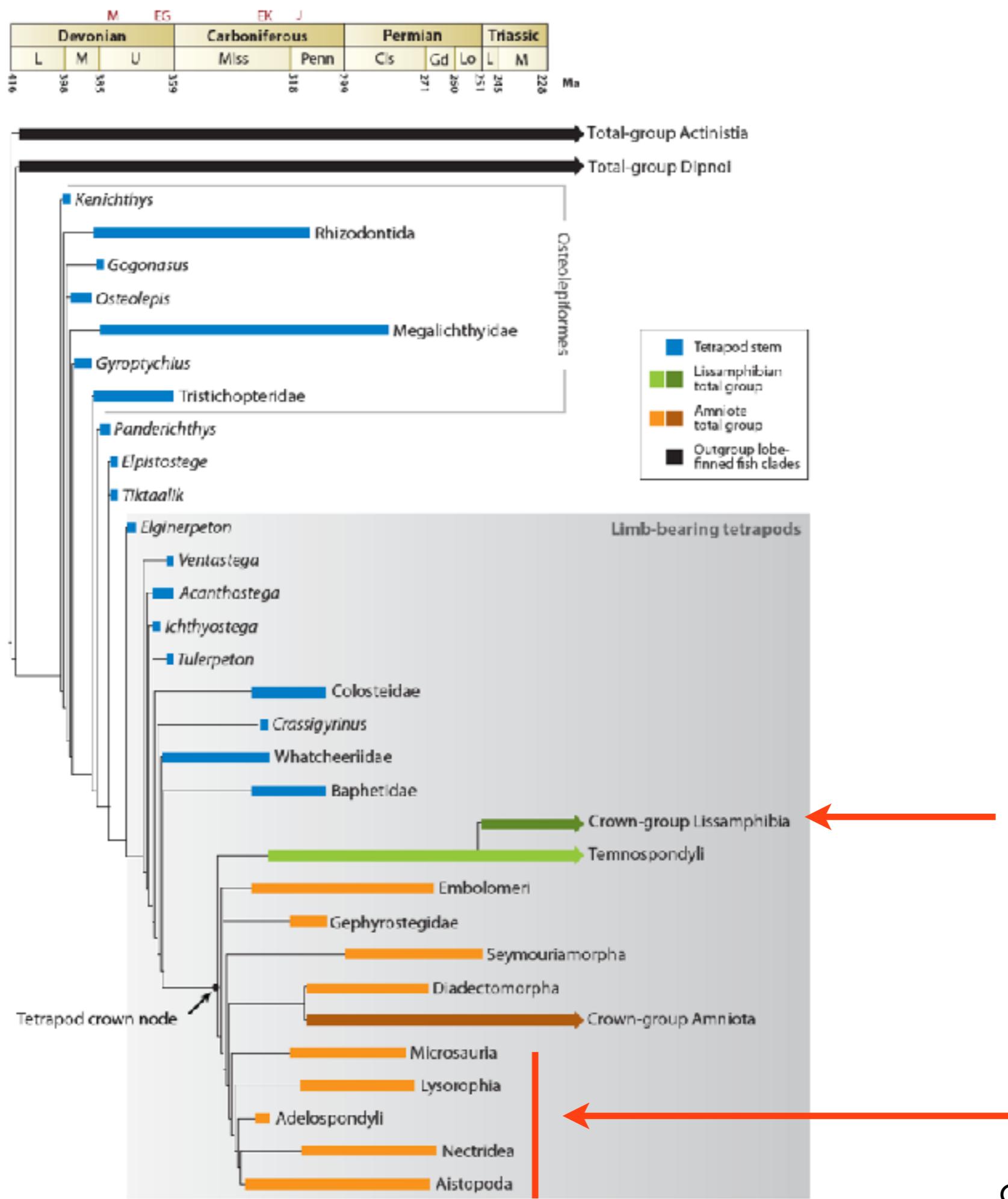
amphibians, reptiles (including birds), and mammals

Crown-group tetrapods illustrate the rapid divergence  
of today's major tetrapod groups:

amphibians, reptiles (including birds), and mammals

but there is also a diversity of tetrapod clades from the  
Carboniferous that left no modern descendants





# Origin of Lissamphibia

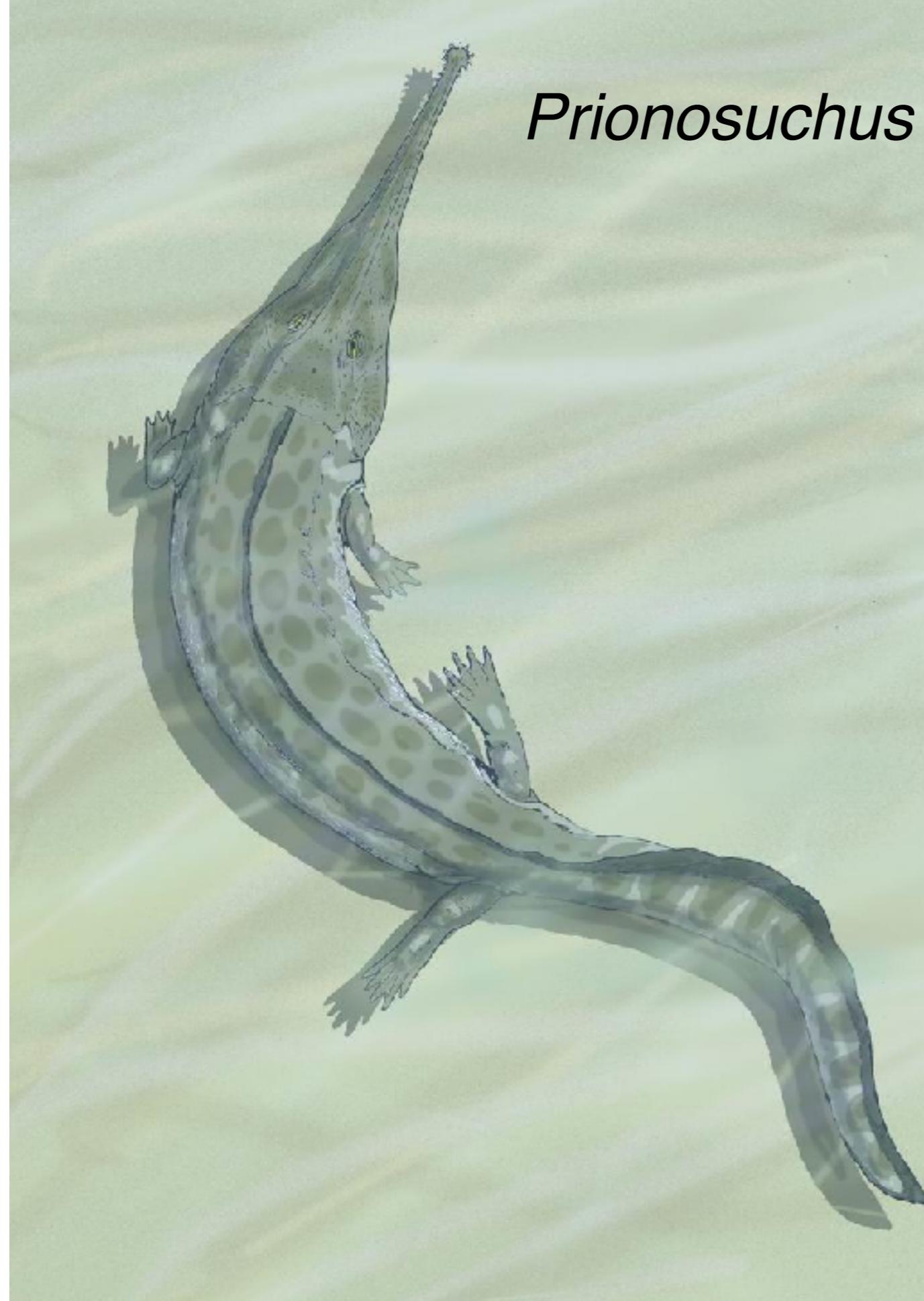
- Their extinct relatives are extremely contentious
- Probably came from one of two groups: Temnospondyls or Lepospondyls
- This is a major unsolved problem in herpetology

# Temnospondyls



wikipedia

*Capetus*

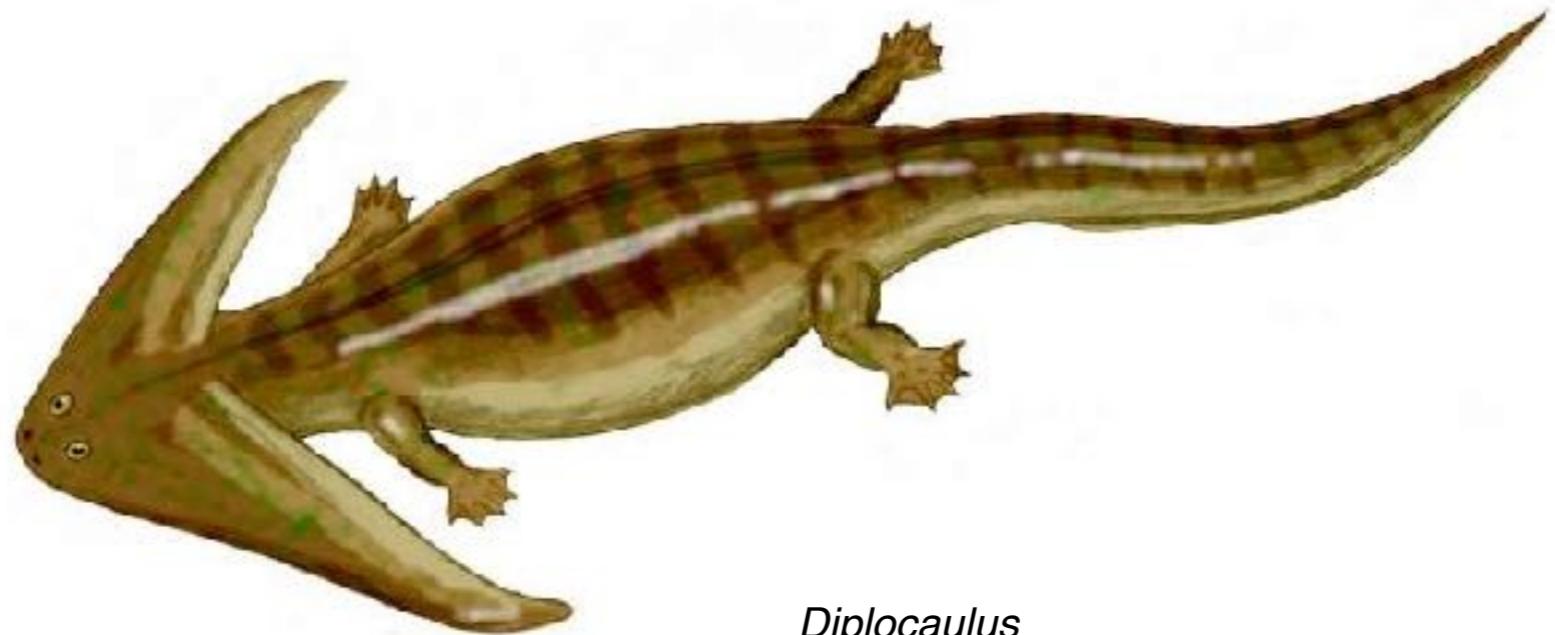


*Prionosuchus*

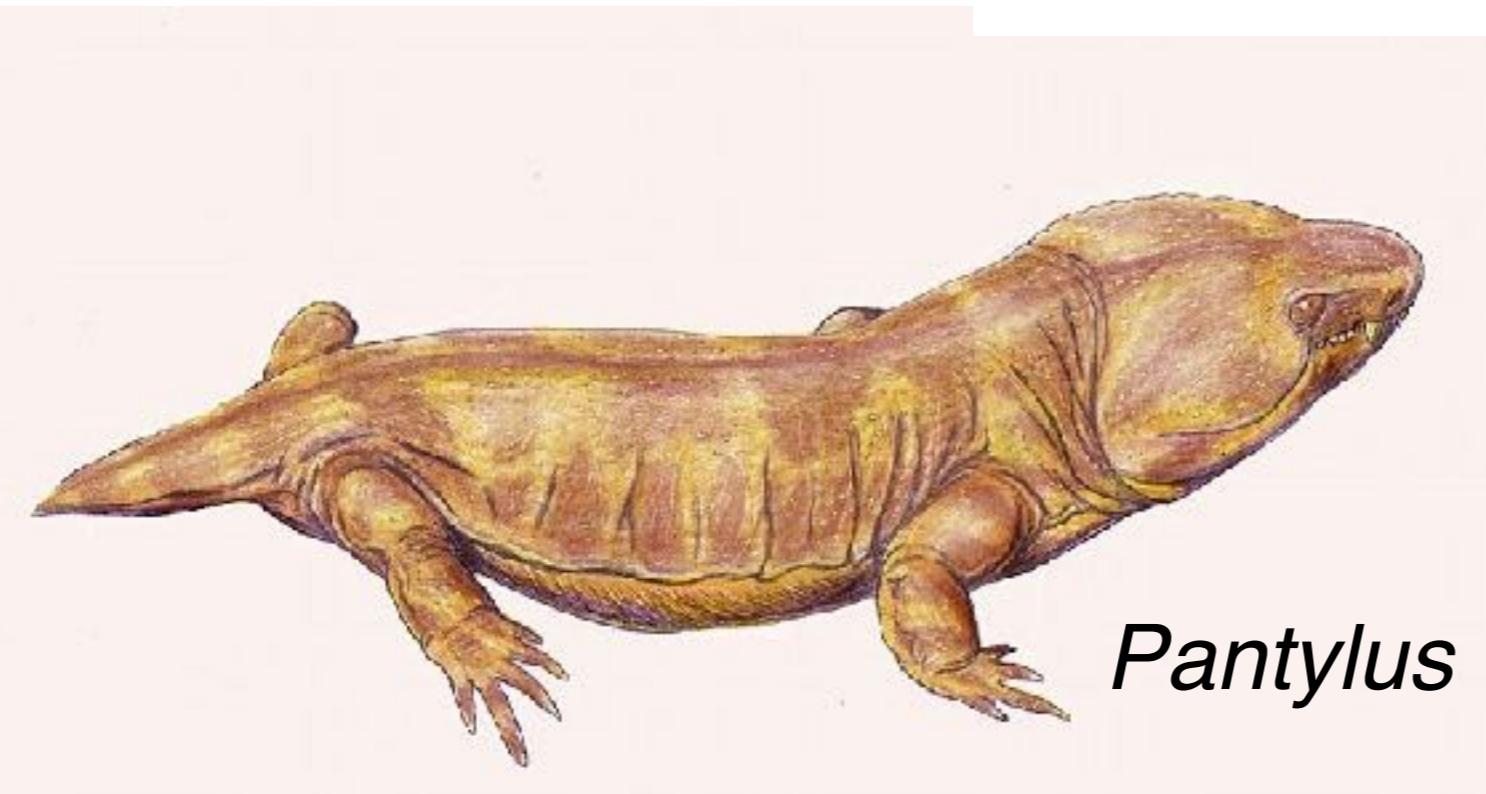
Temnospondyls

~270 mya  
9 m long -  
largest amphibian

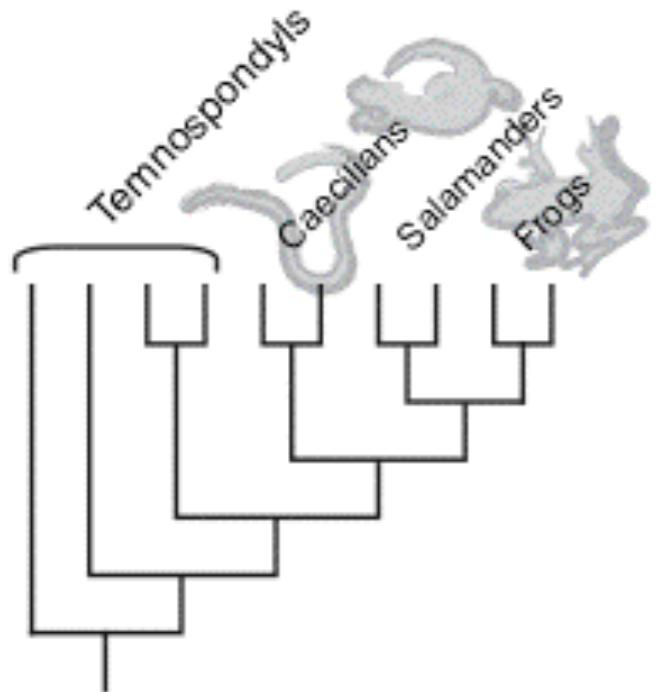
# Lepospondyls



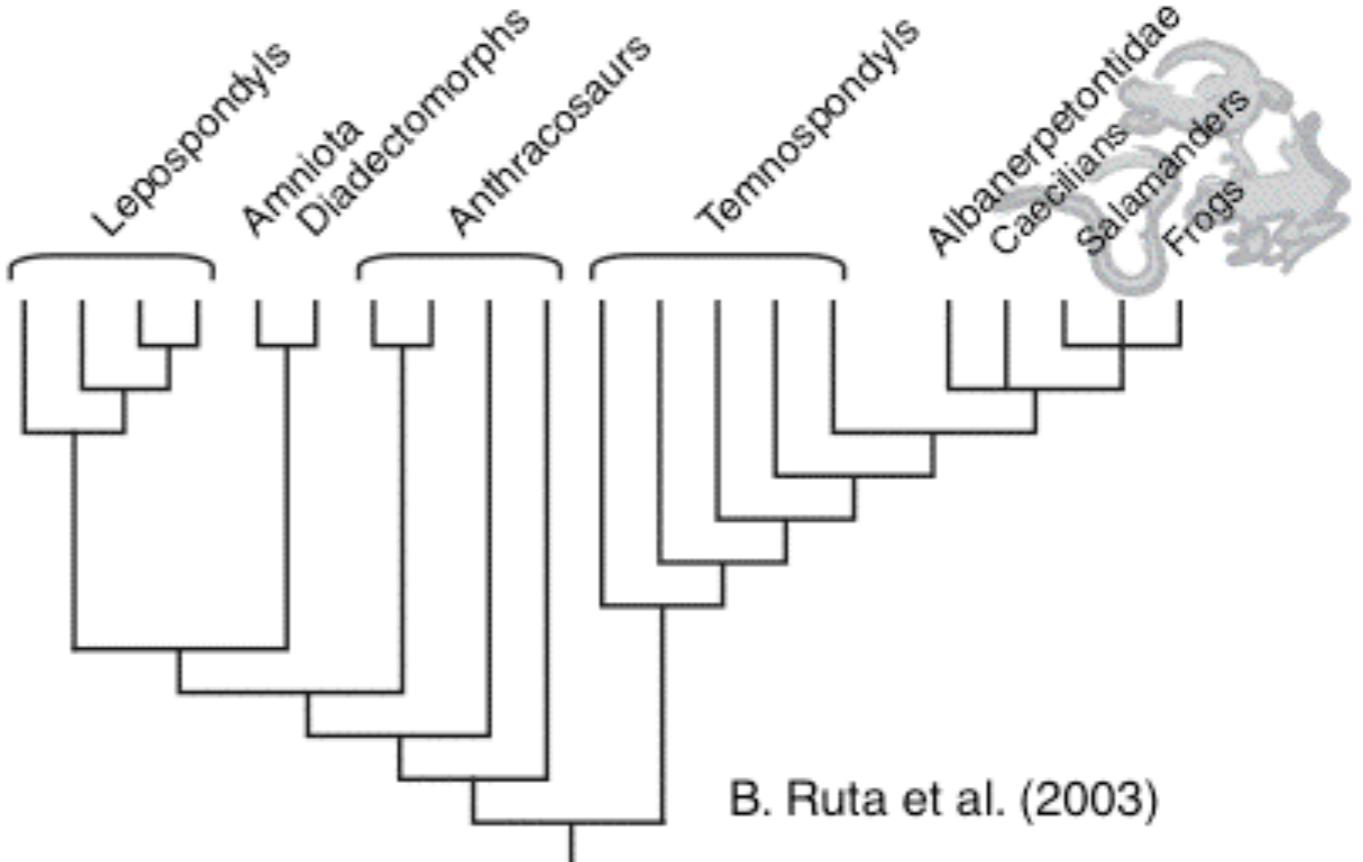
*Diplocaulus*



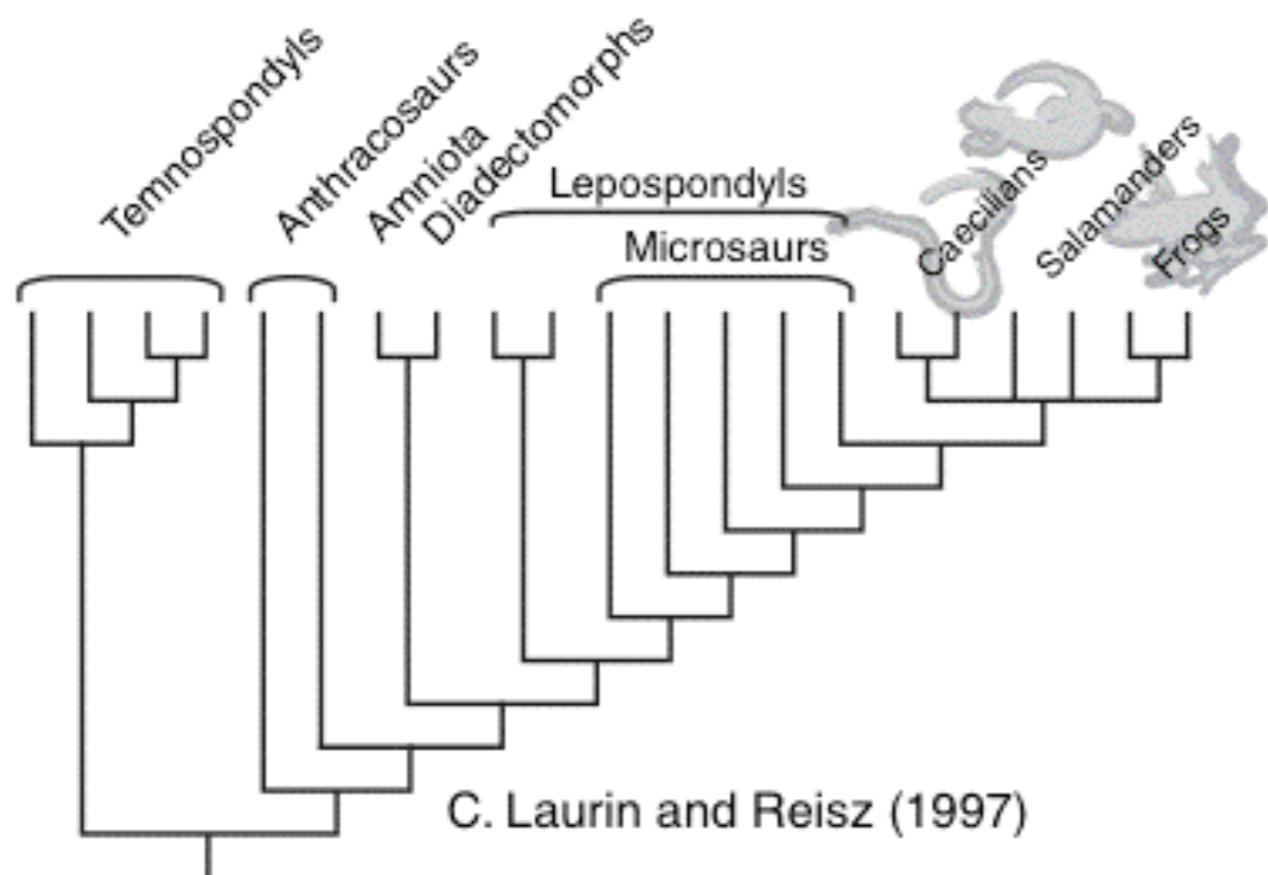
*Pantylus*



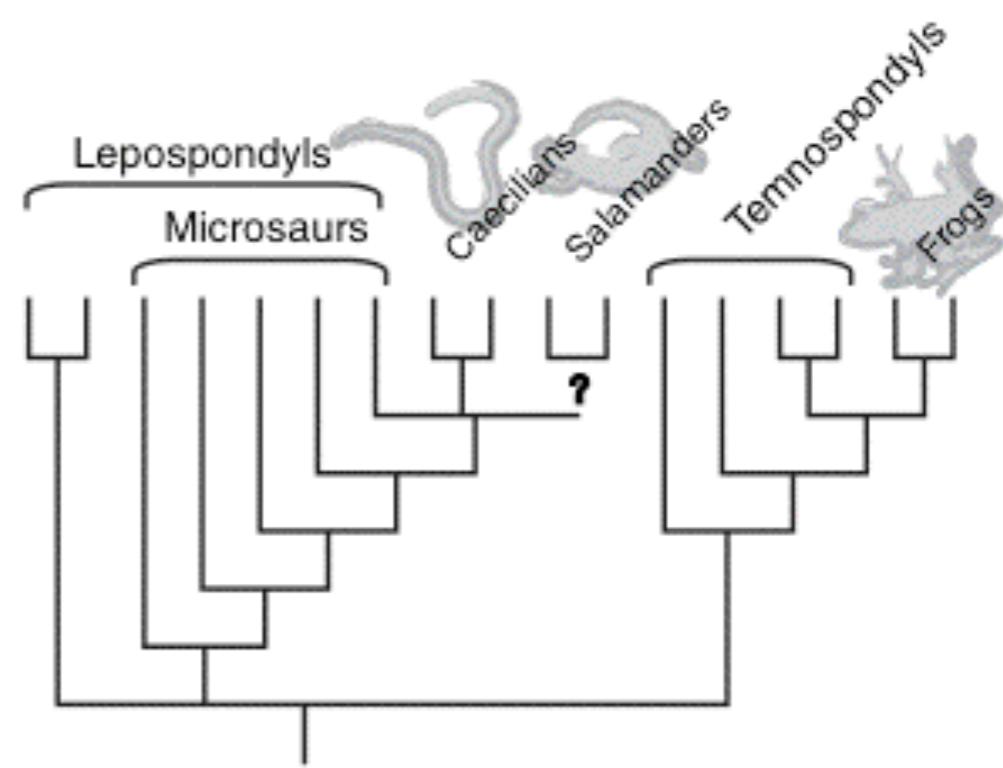
A. Trueb and Cloutier (1991)



B. Ruta et al. (2003)

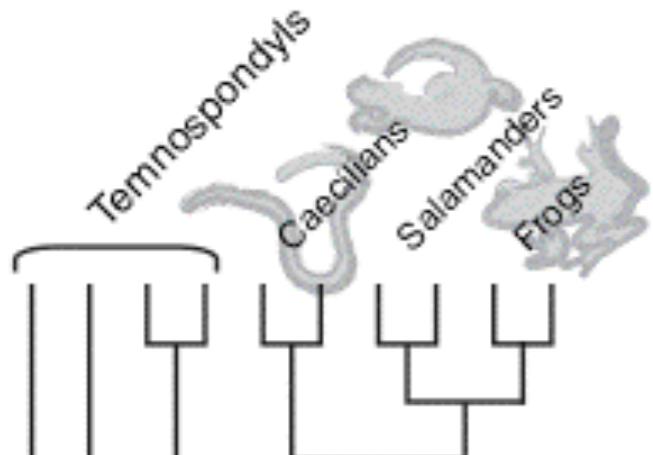


C. Laurin and Reisz (1997)

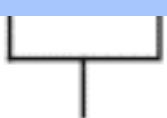


D. Carroll (2000)

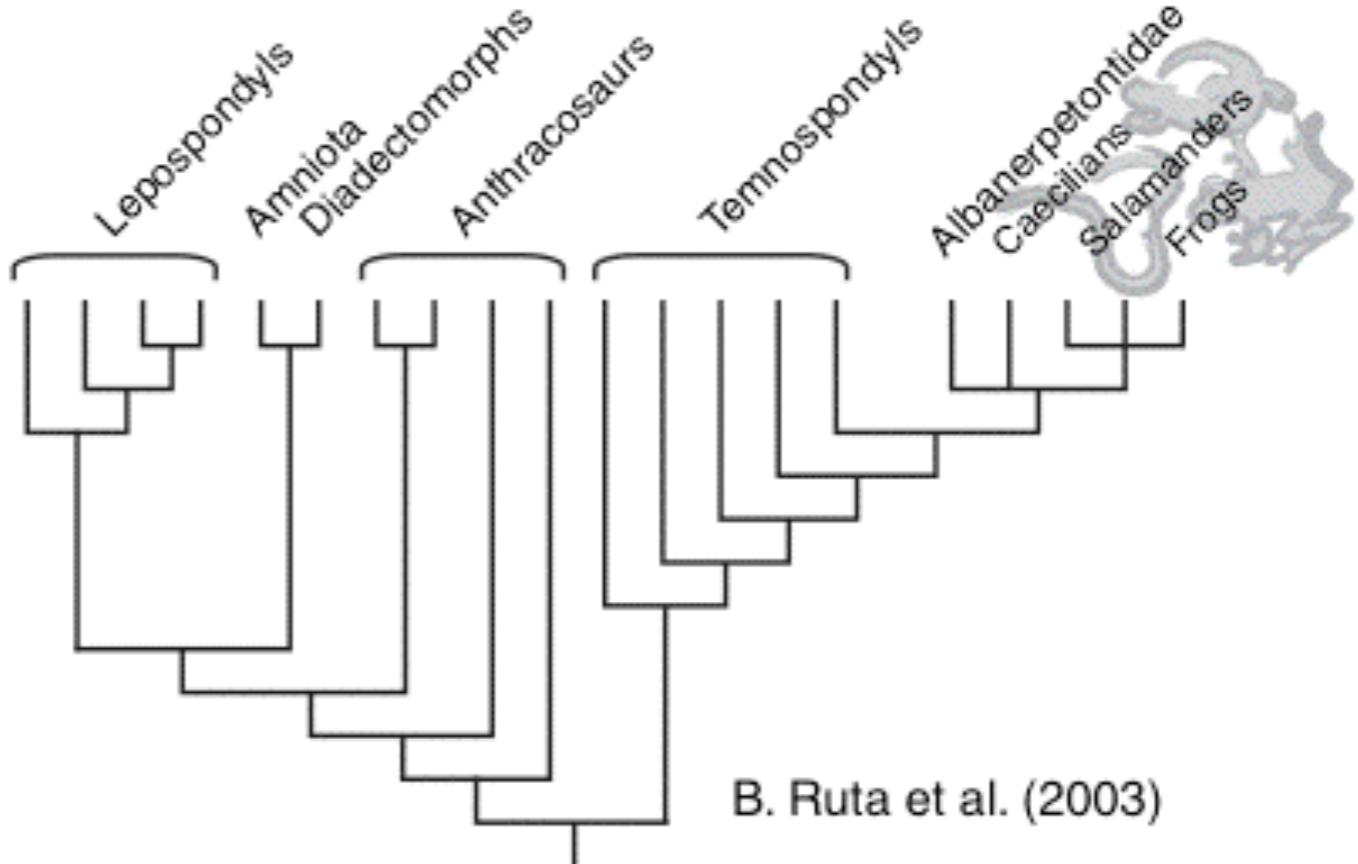
**Figure 25.2.** (A–D) Alternative relationships among modern amphibians (caecilians, frogs, and salamanders) and Paleozoic groups (temnospondyls, microsaurs, and lepospondyls).



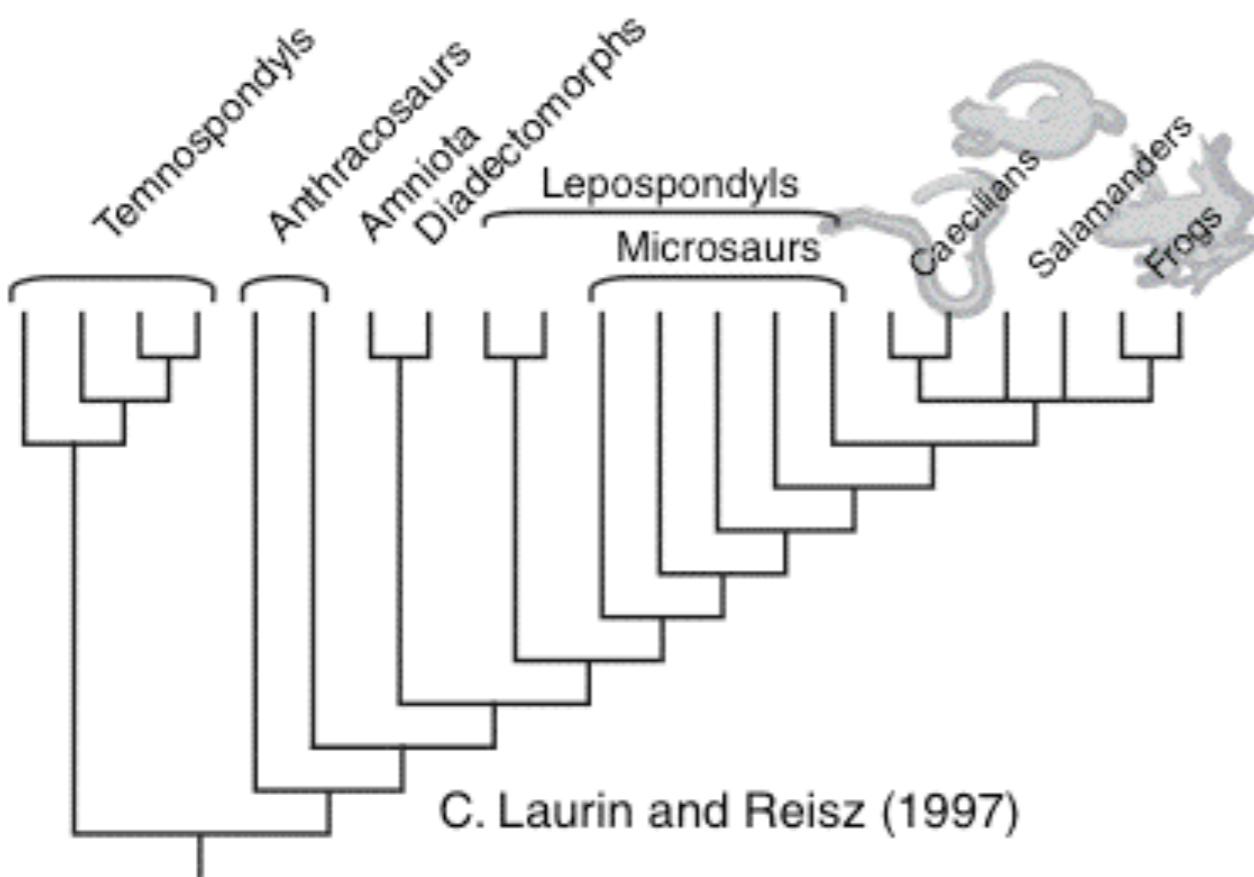
## From temnospondyls



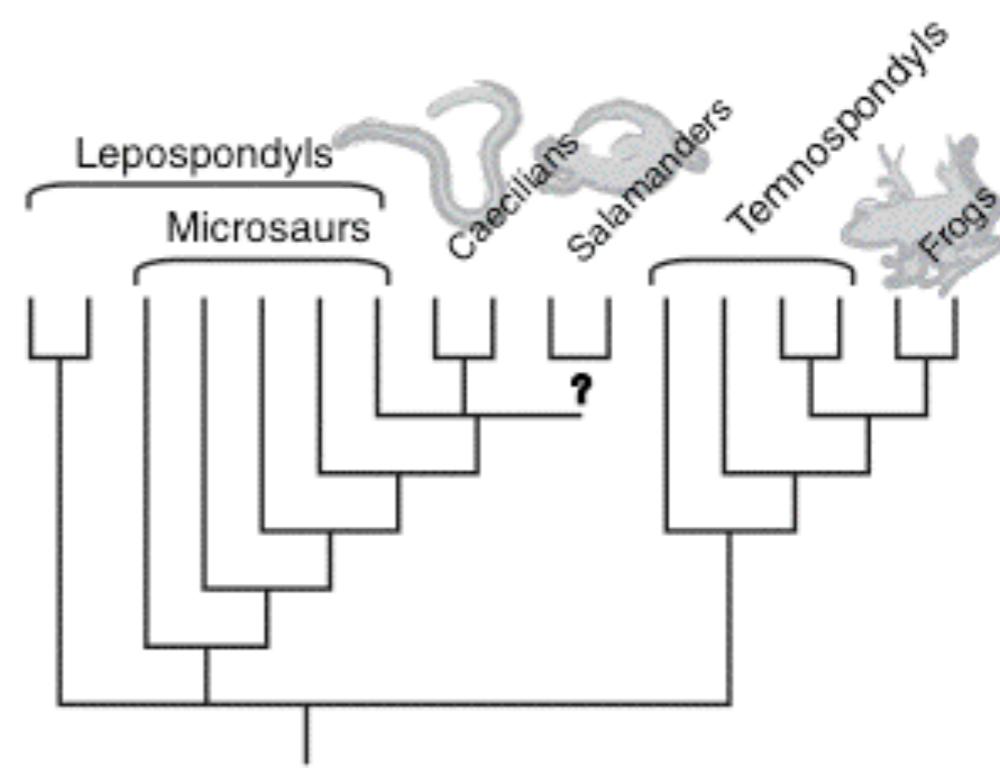
A. Trueb and Cloutier (1991)



B. Ruta et al. (2003)

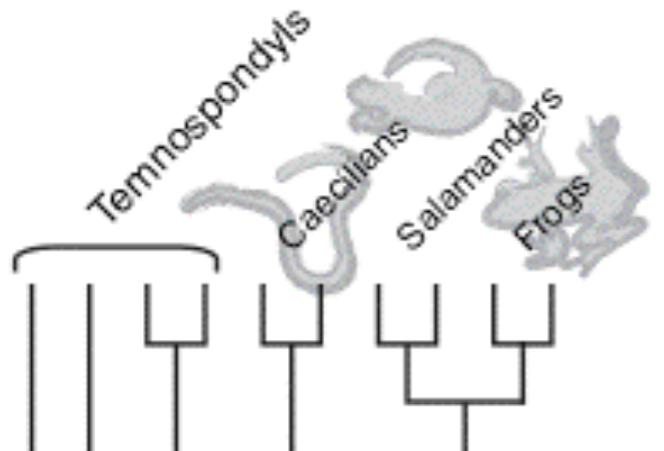


C. Laurin and Reisz (1997)

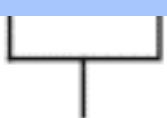


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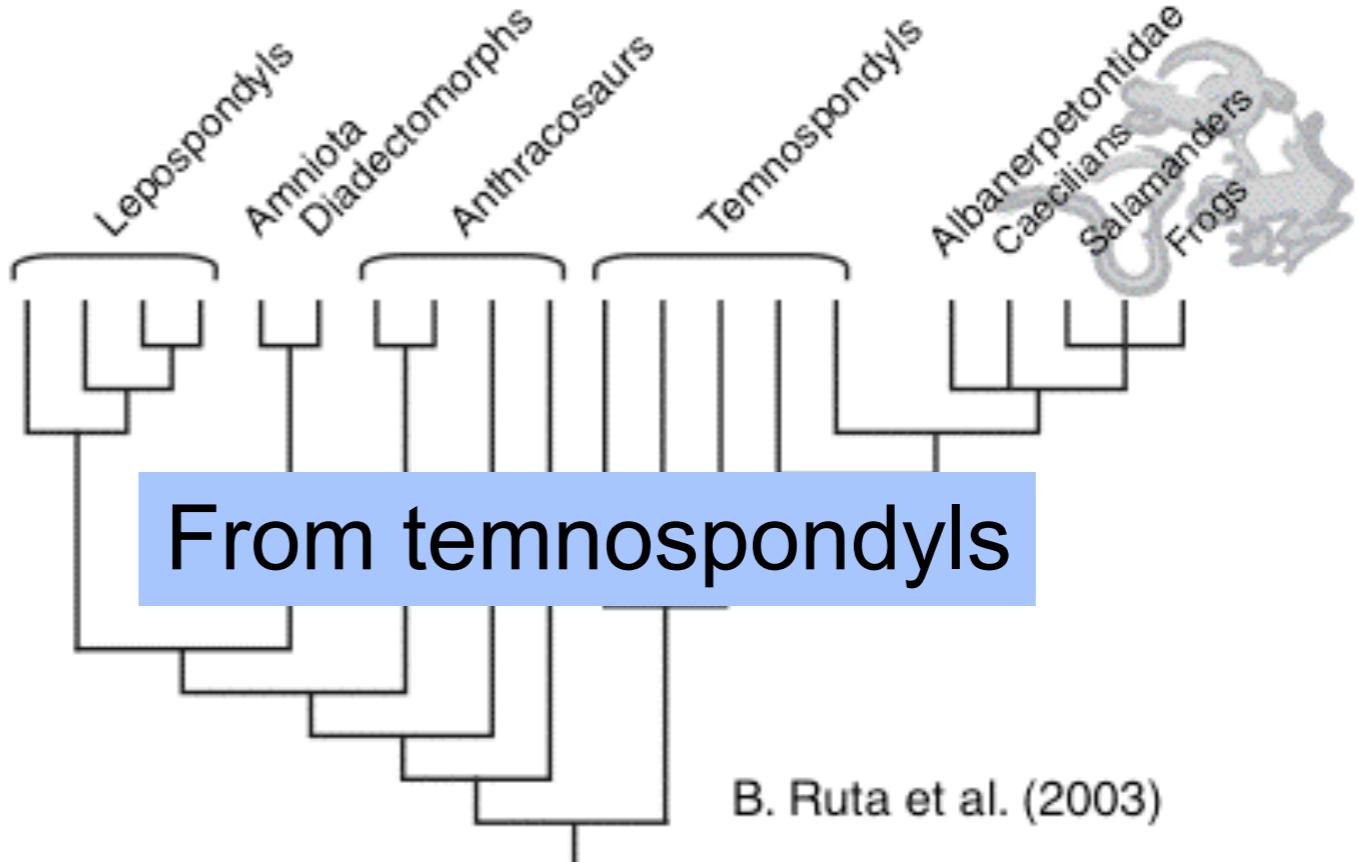
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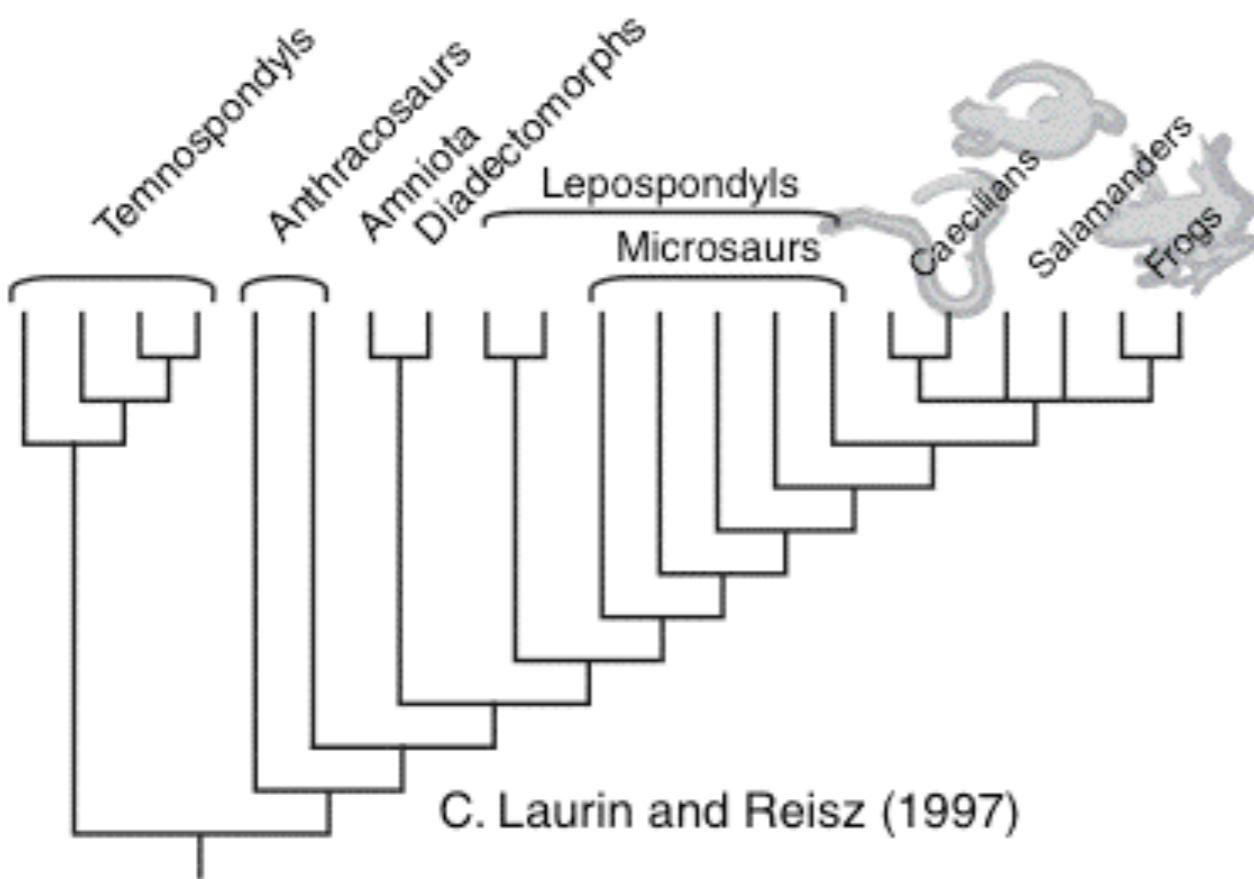


A. Trueb and Cloutier (1991)

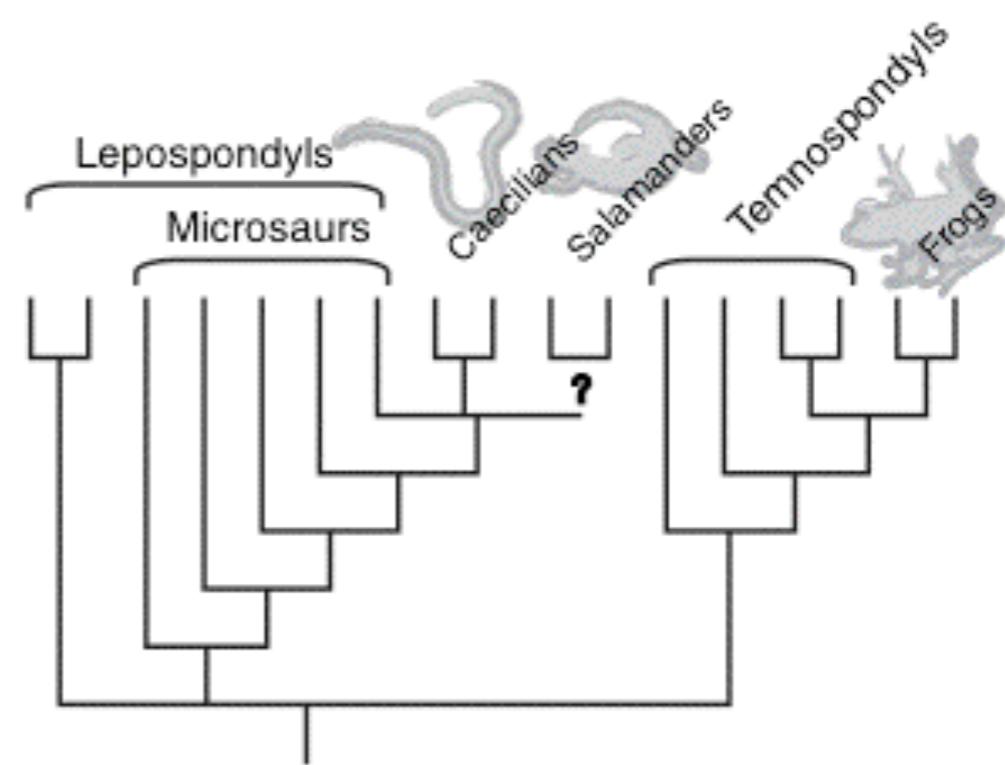


**From temnospondyls**

B. Ruta et al. (2003)

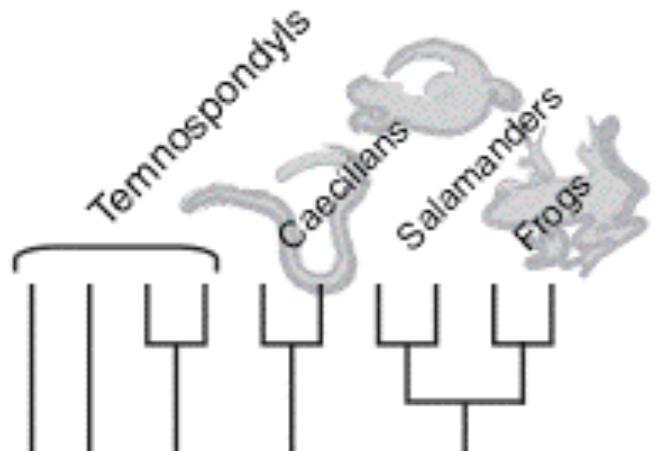


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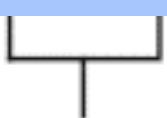


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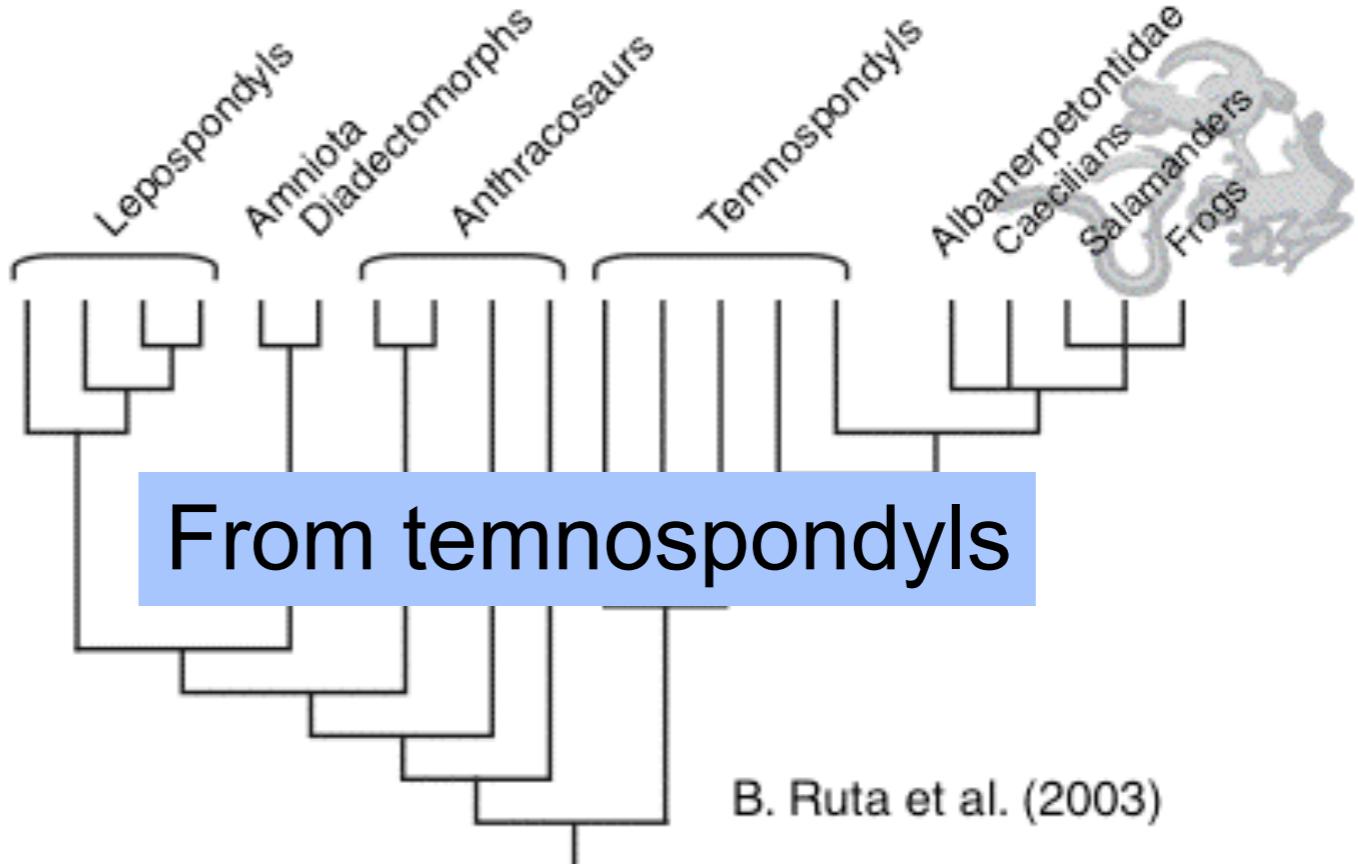
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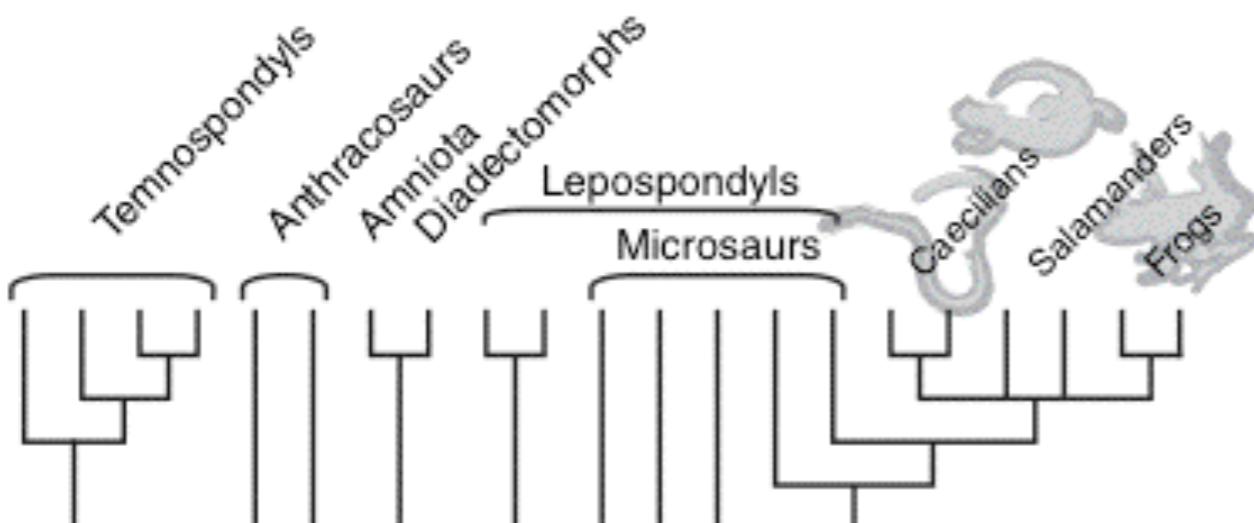


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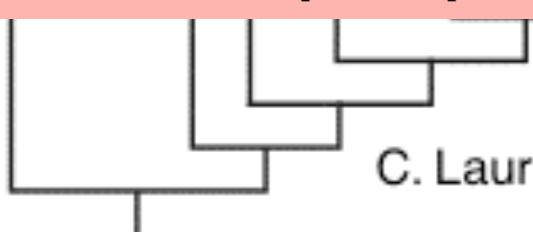


**From temnospondyls**

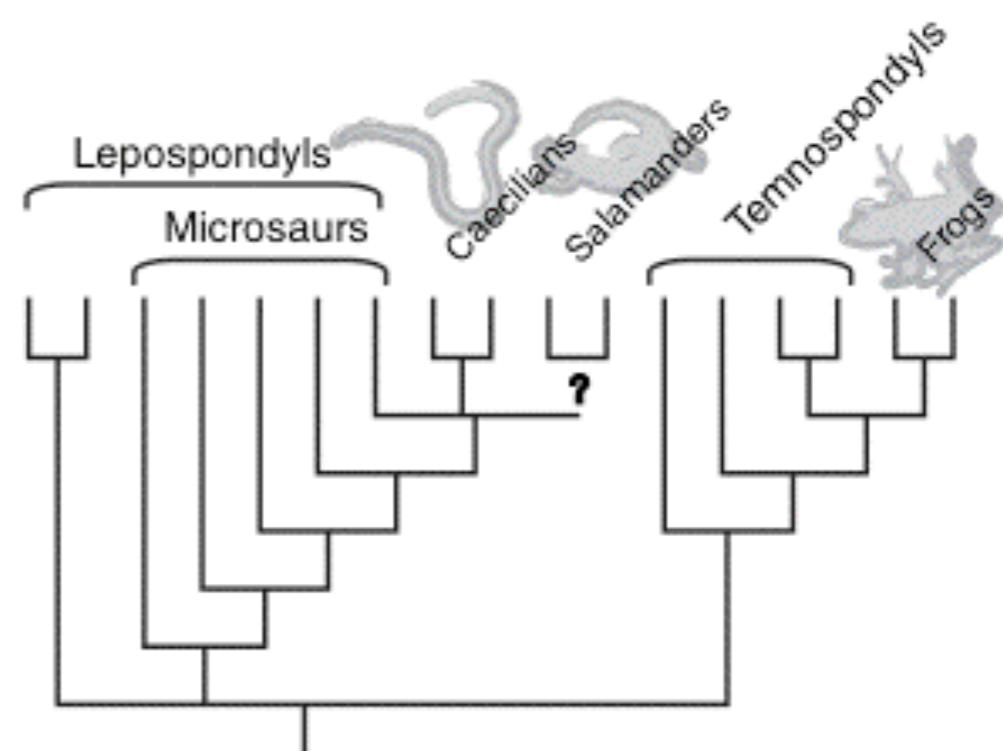
B. Ruta et al. (2003)



**From lepospondyls**

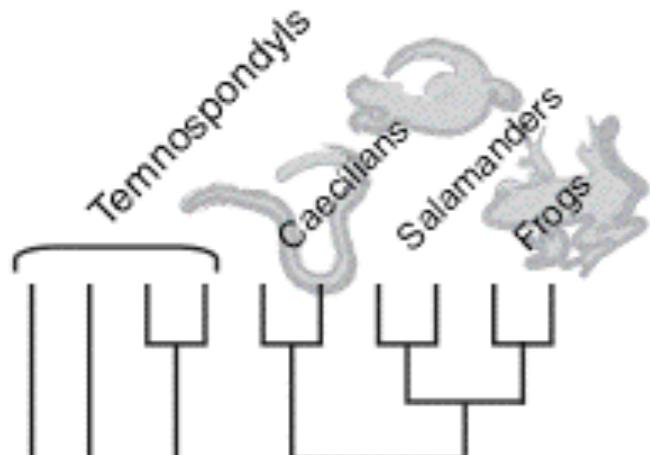


C. Laurin and Reisz (1997)

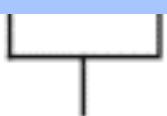


D. Carroll (2000)

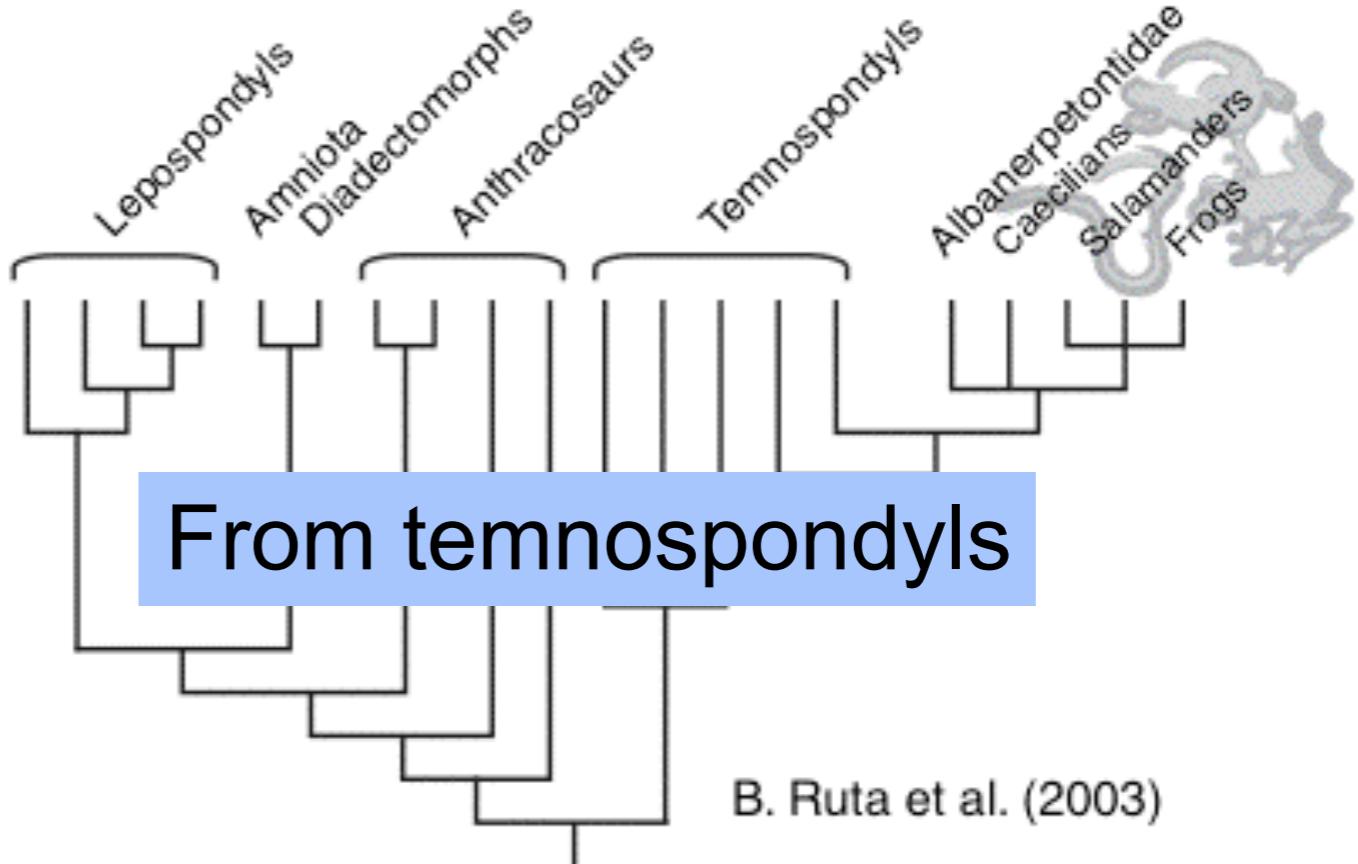
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**From temnospondyls**

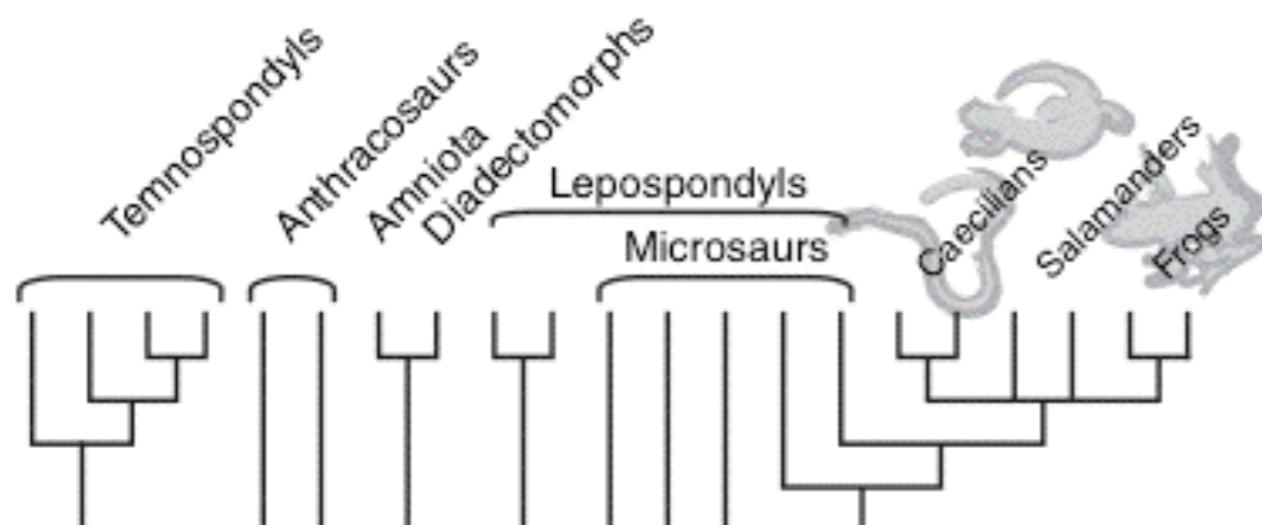


A. Trueb and Cloutier (1991)

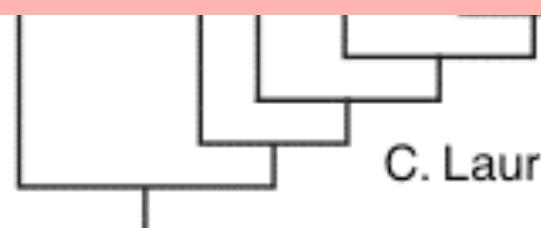


**From temnospondyls**

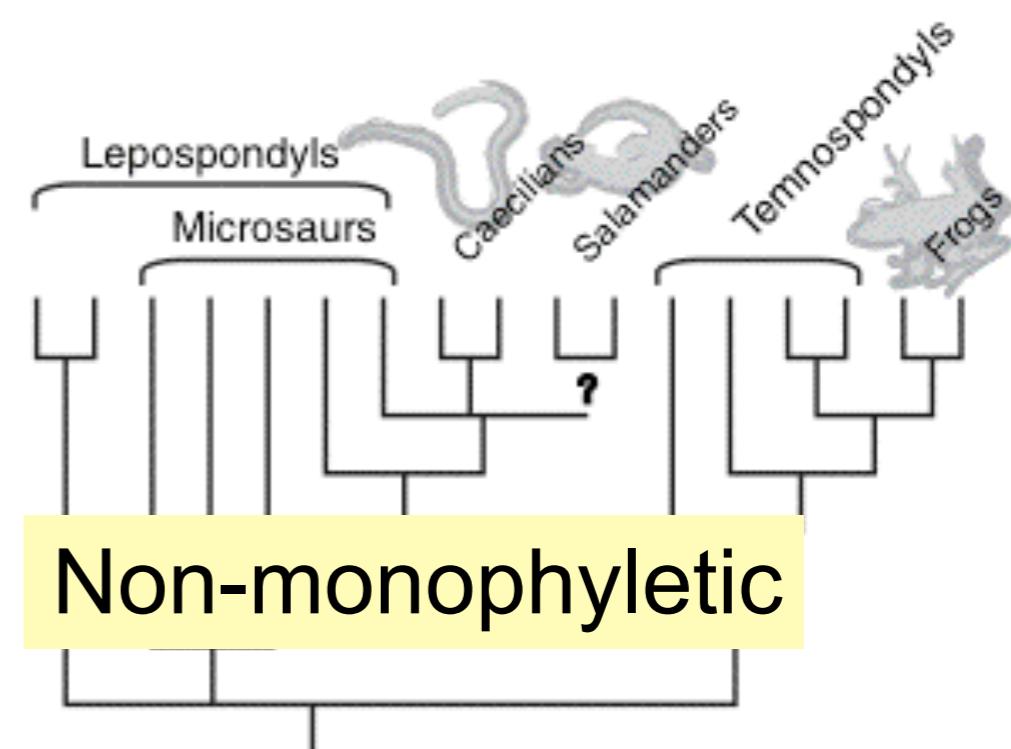
B. Ruta et al. (2003)



**From lepospondyls**



C. Laurin and Reisz (1997)



**Non-monophyletic**

D. Carroll (2000)

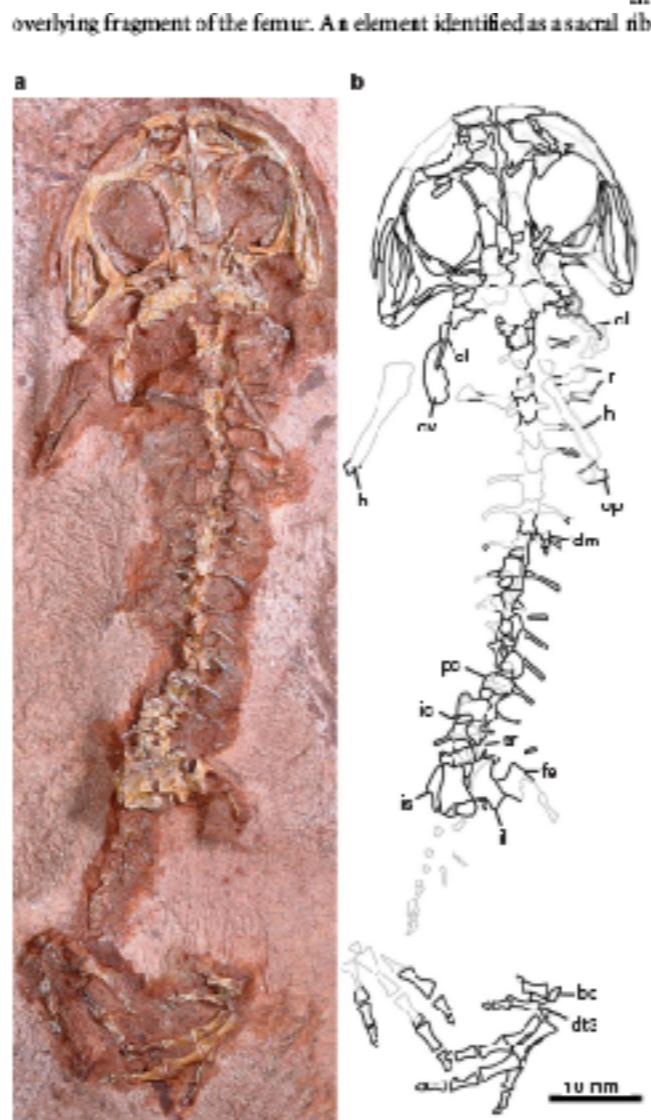
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## LETTERS

## A stem batrachian from the Early Permian of Texas and the origin of frogs and salamanders

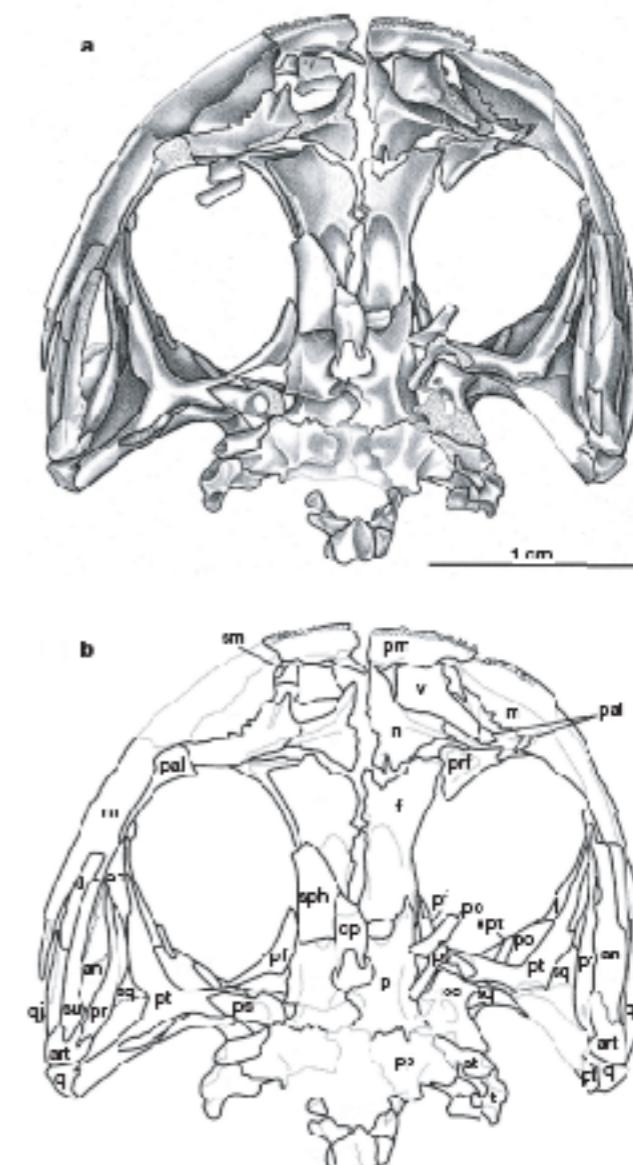
Jason S. Anderson<sup>1</sup>, Robert R. Reisz<sup>2</sup>, Diane Scott<sup>2</sup>, Nadia B. Fröbisch<sup>3</sup> & Stuart S. Sumida<sup>4</sup>

### *Gerobatrachus*



**Figure 1 |** *Gerobatrachus houstonensis*, gen. et sp. nov., holotype specimen USNM 489135. Complete specimen in ventral view, photograph (left) and interpretive cutline drawing (right). Abbreviations: bc, basale concone; d, cleithrum; cv, clavicle; dm, digital elements of the manus; dt3, distal tarzal3; fe, femur; h, humerus; ic, intercentrum; il, ilium; is, ischium; op, olecranon process of ulna; pc, pleurocentrum; r, radius; sr, sacral rib.

articulate with the proximal surfaces of metatarsals 1 and 2, it would

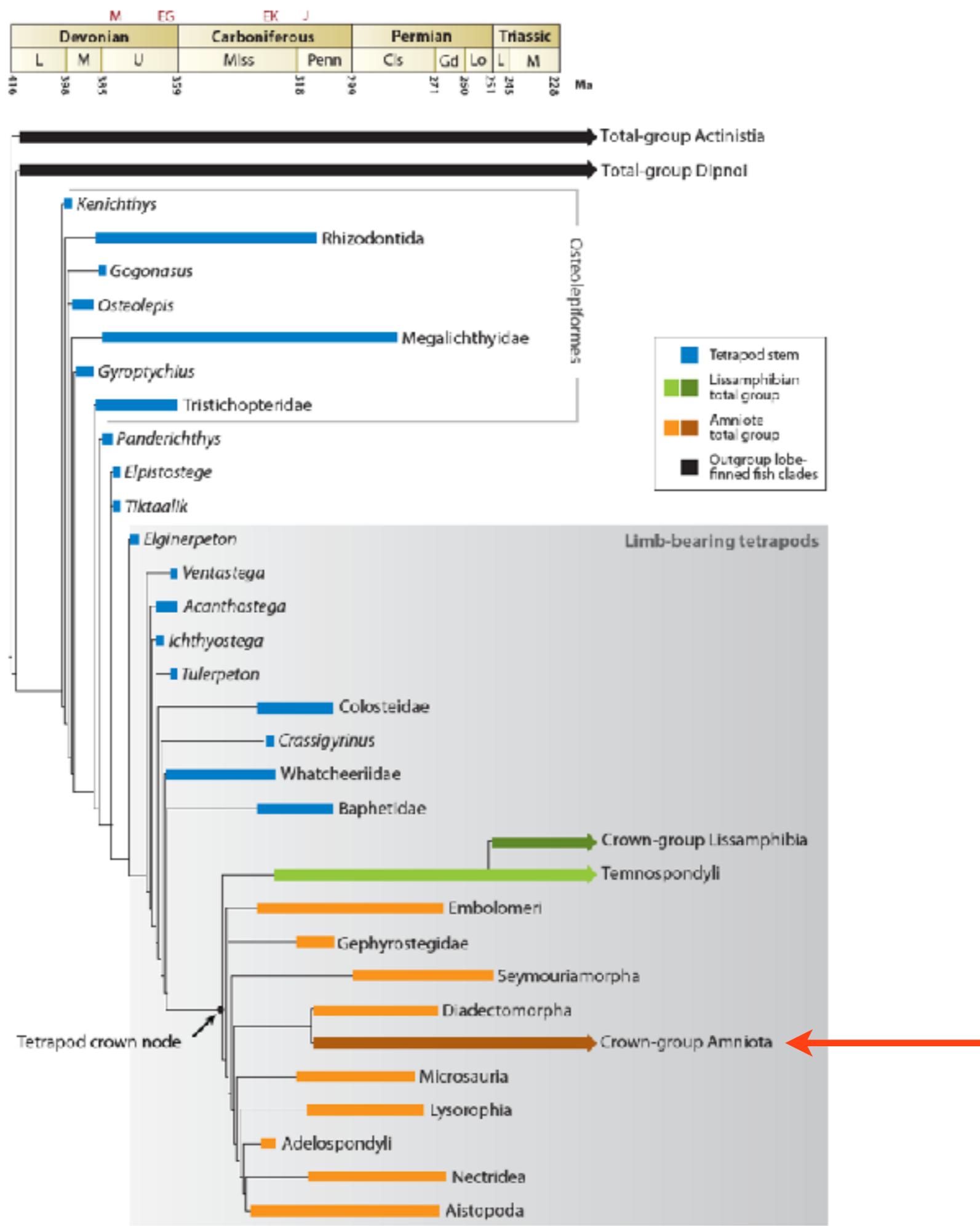


Anderson et al. 2008

*Gerobatrachus*:  
The “frogamander”

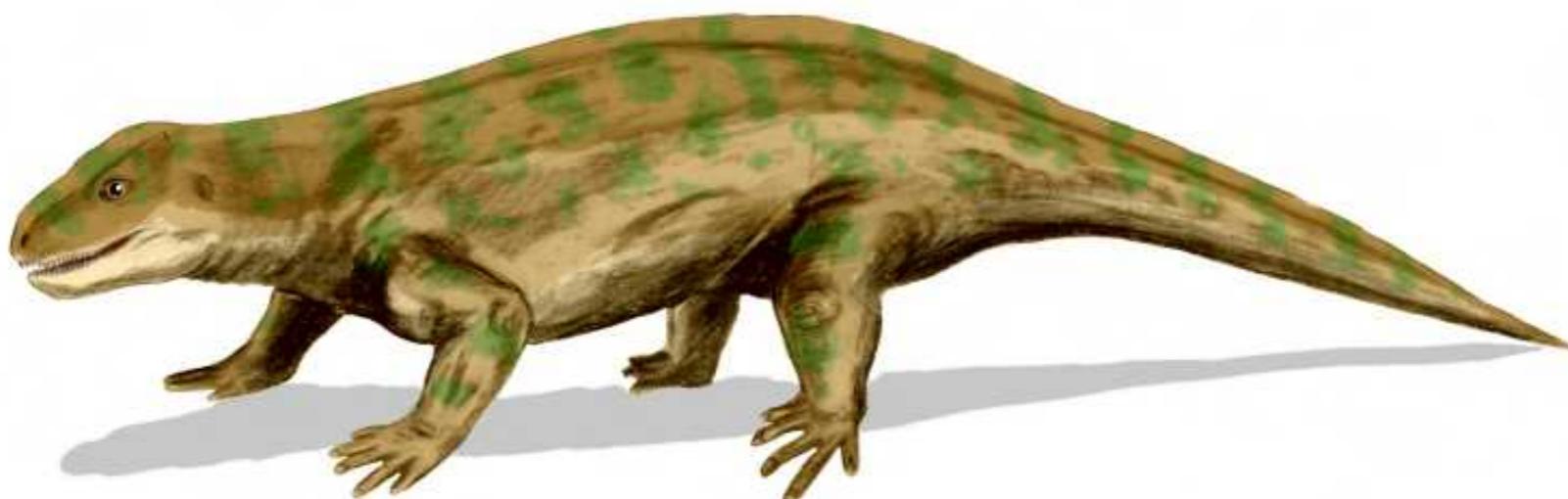


Art by Michael Skrepnick



# Early Evolution in Amniotes

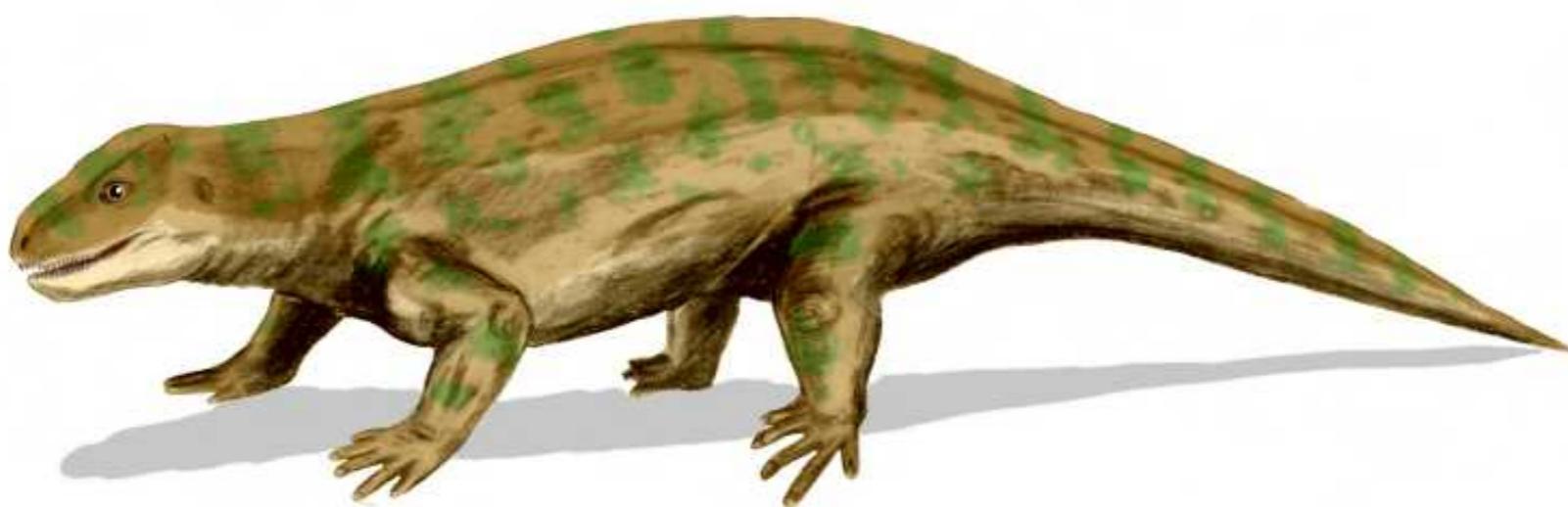
- Amniota derives from the possession of an amniotic egg
- Sister group to amniotes: *Diadectomorpha*



Diadectes, from wikipedia

# Early Evolution in Amniotes

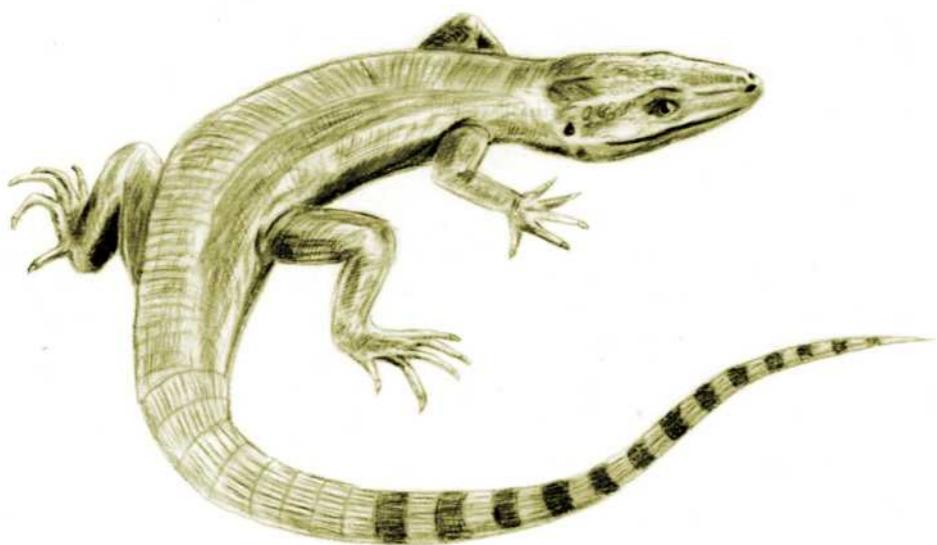
- A large number of derived traits are shared by didactomorphs and amniotes
- Soon after, there is a major split in the amniotes



Diadectes, from wikipedia

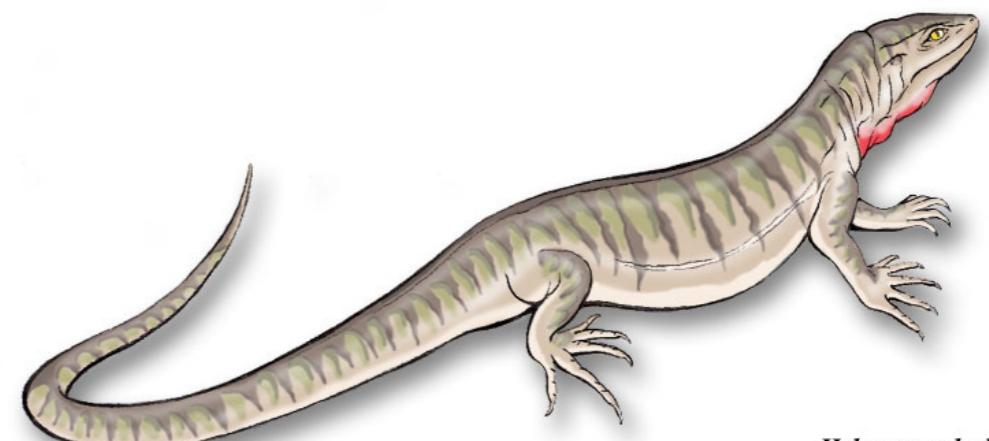
# Division in the amniotes

## Synapsids



*Archaeothyris*,  
an early synapsid

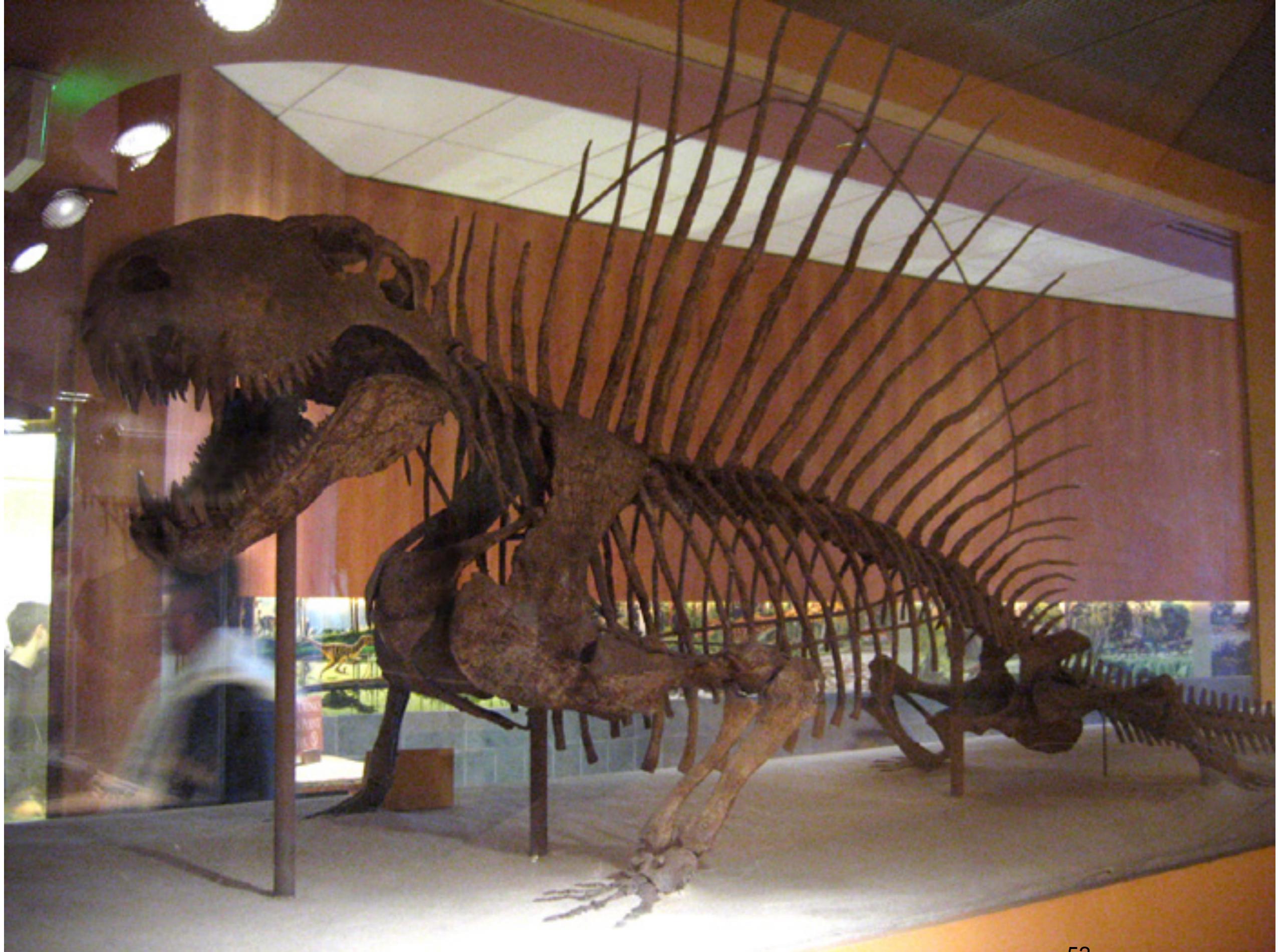
## Reptiles



*Hylonomus lyelli*

Illustration by Donald Agnew  
Joggins Fossil Cliffs Project - CREDA

*Hylonomus*,  
an early reptile



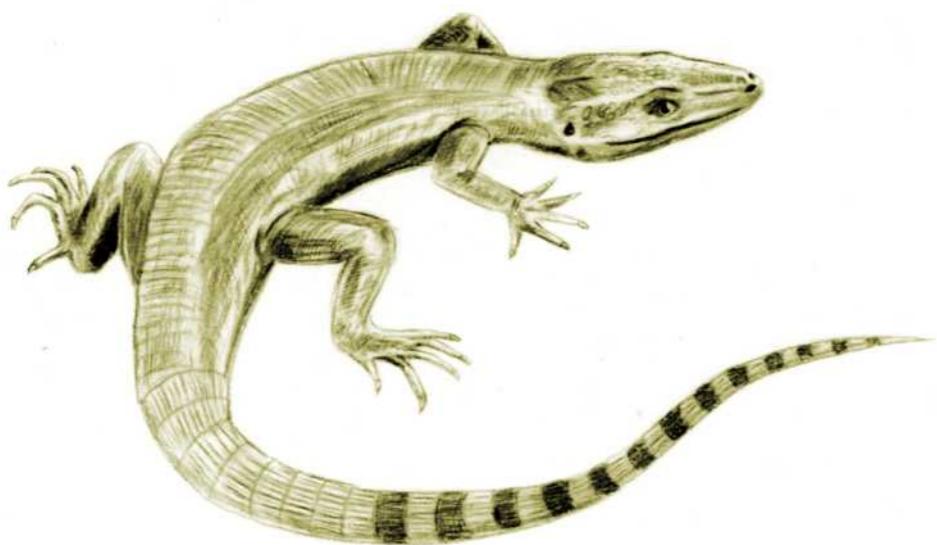
Fossil skeleton of *Dimetrodon grandis*, National Museum of Natural History, Washington, DC.



# Cynognathus

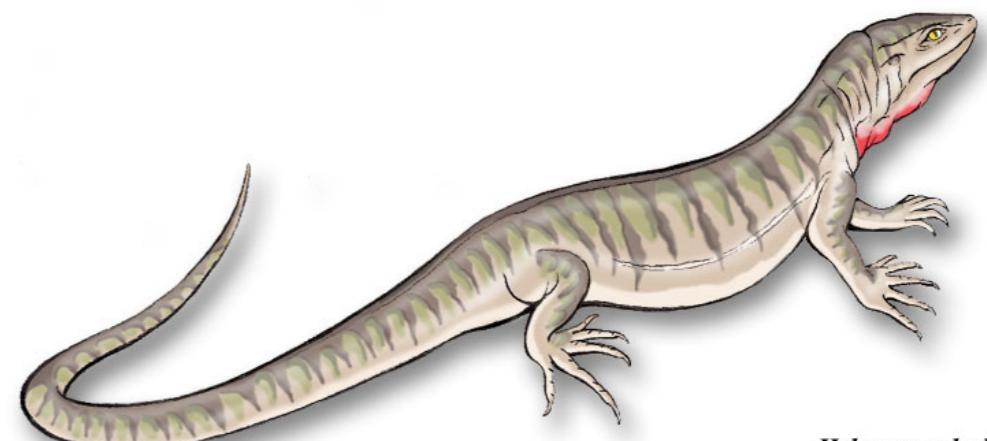
# Division in the amniotes

## Synapsids



*Archaeothyris*,  
an early synapsid

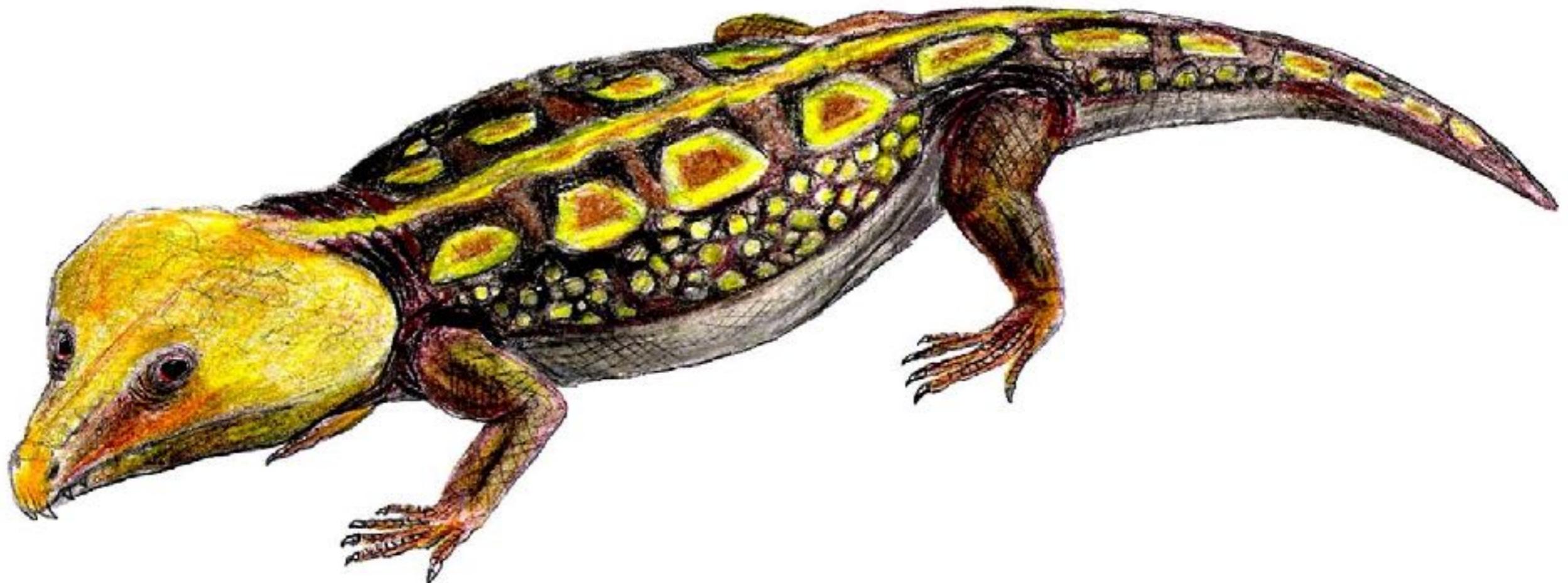
## Reptiles



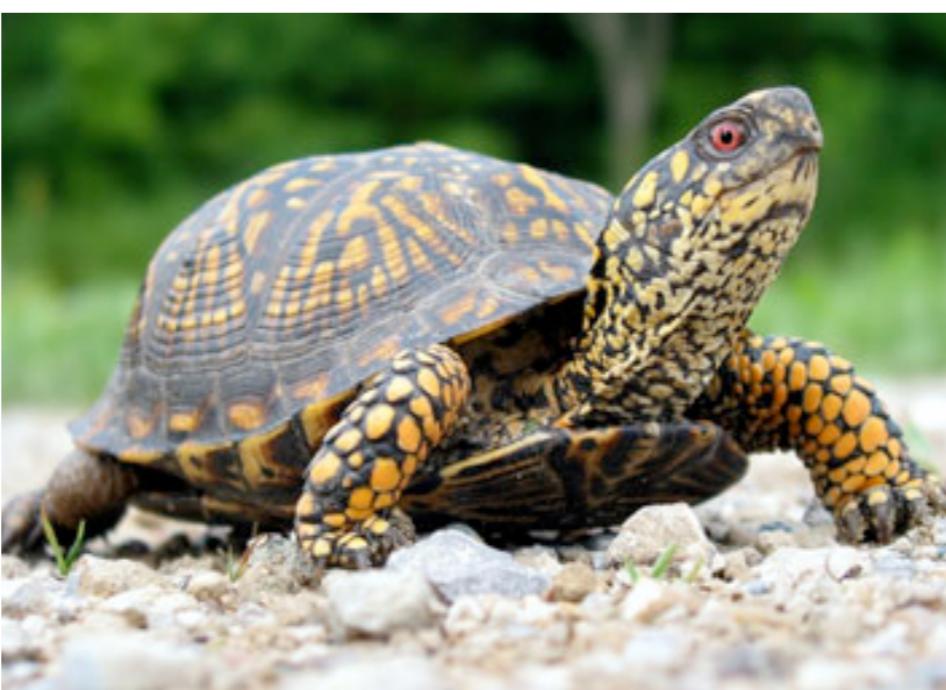
*Hylonomus lyelli*

Illustration by Donald Agnew  
Joggins Fossil Cliffs Project - CREDA

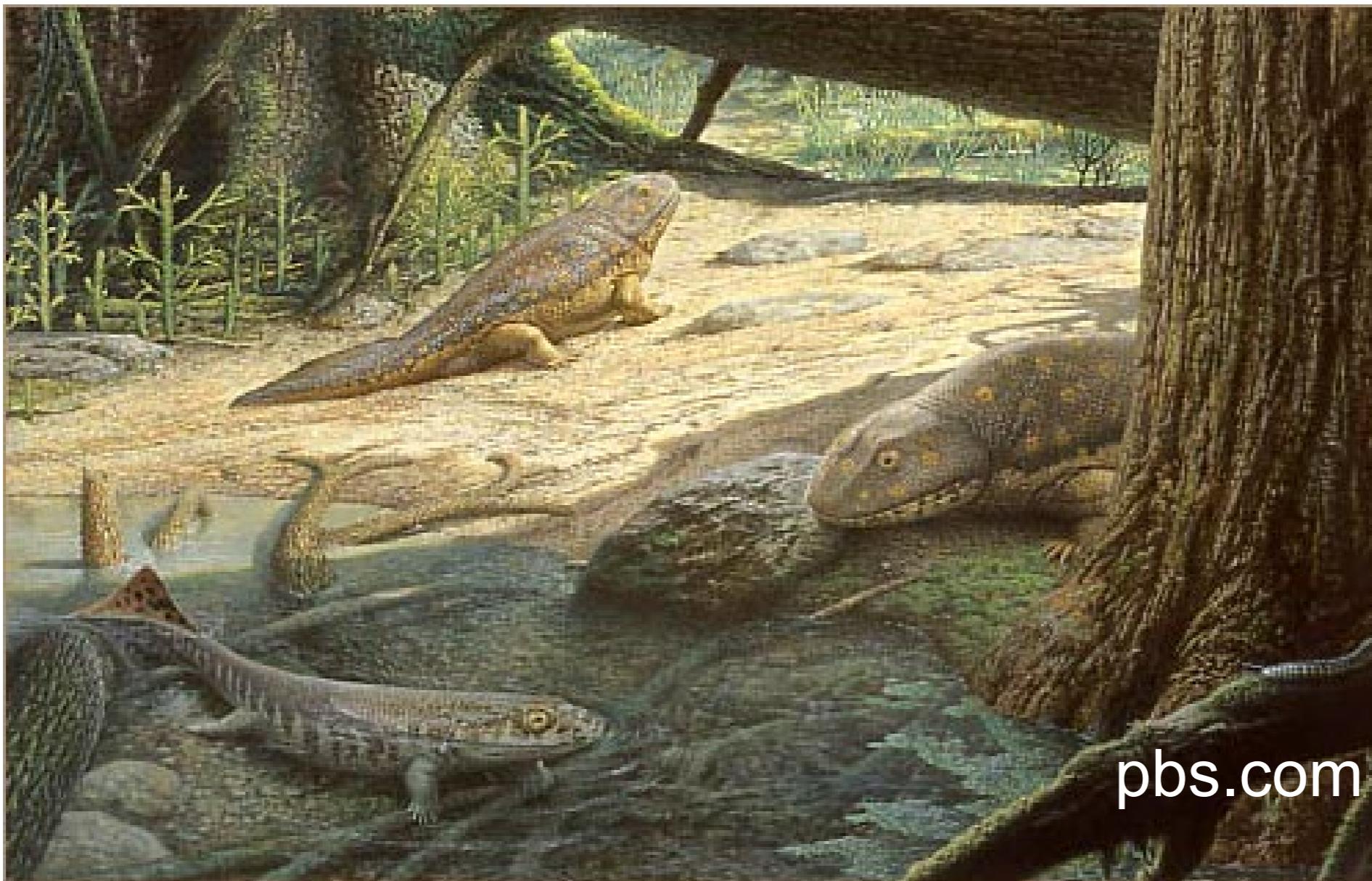
*Hylonomus*,  
an early reptile



*Labidosaurus hamatus.*

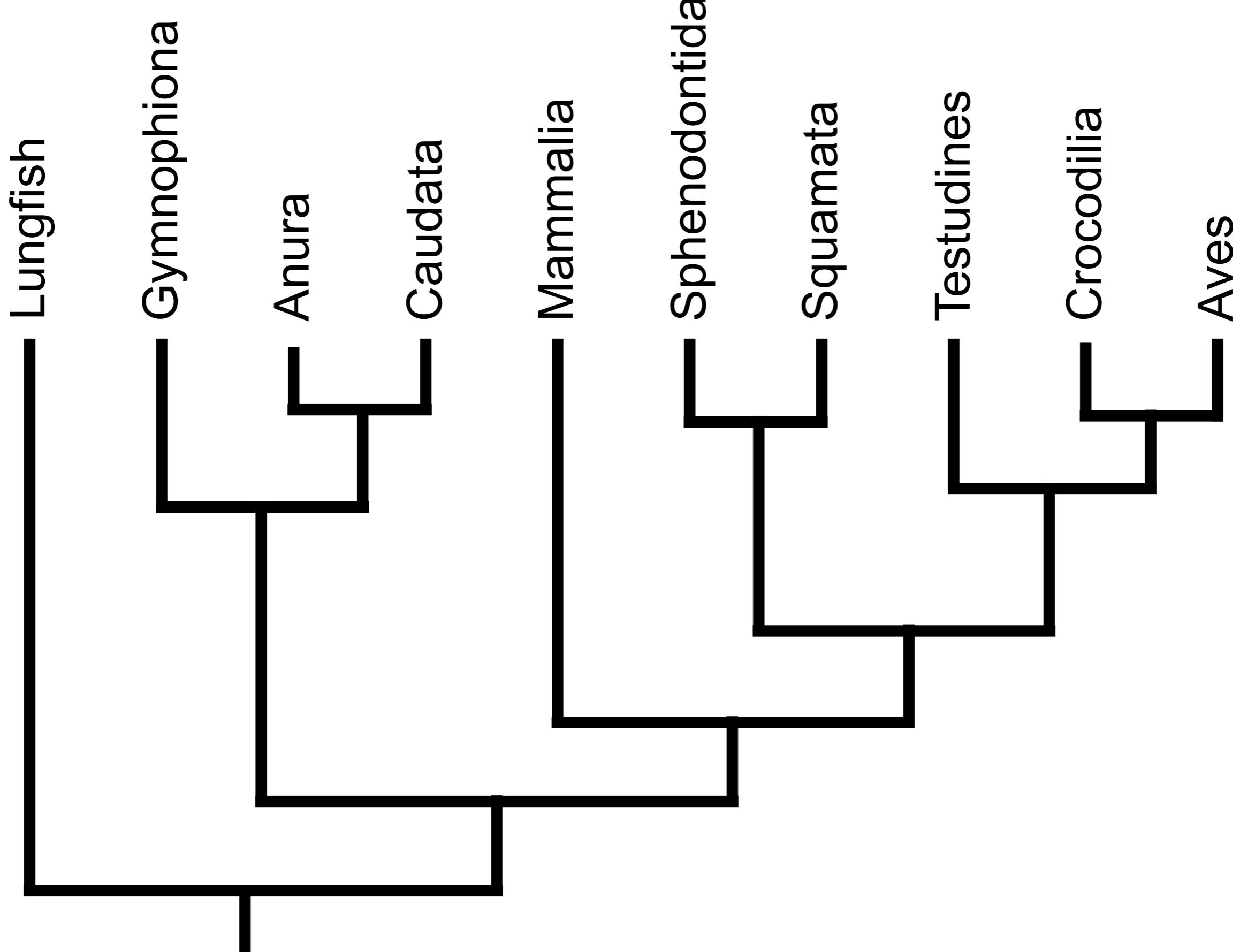


# Overview of tetrapod diversity

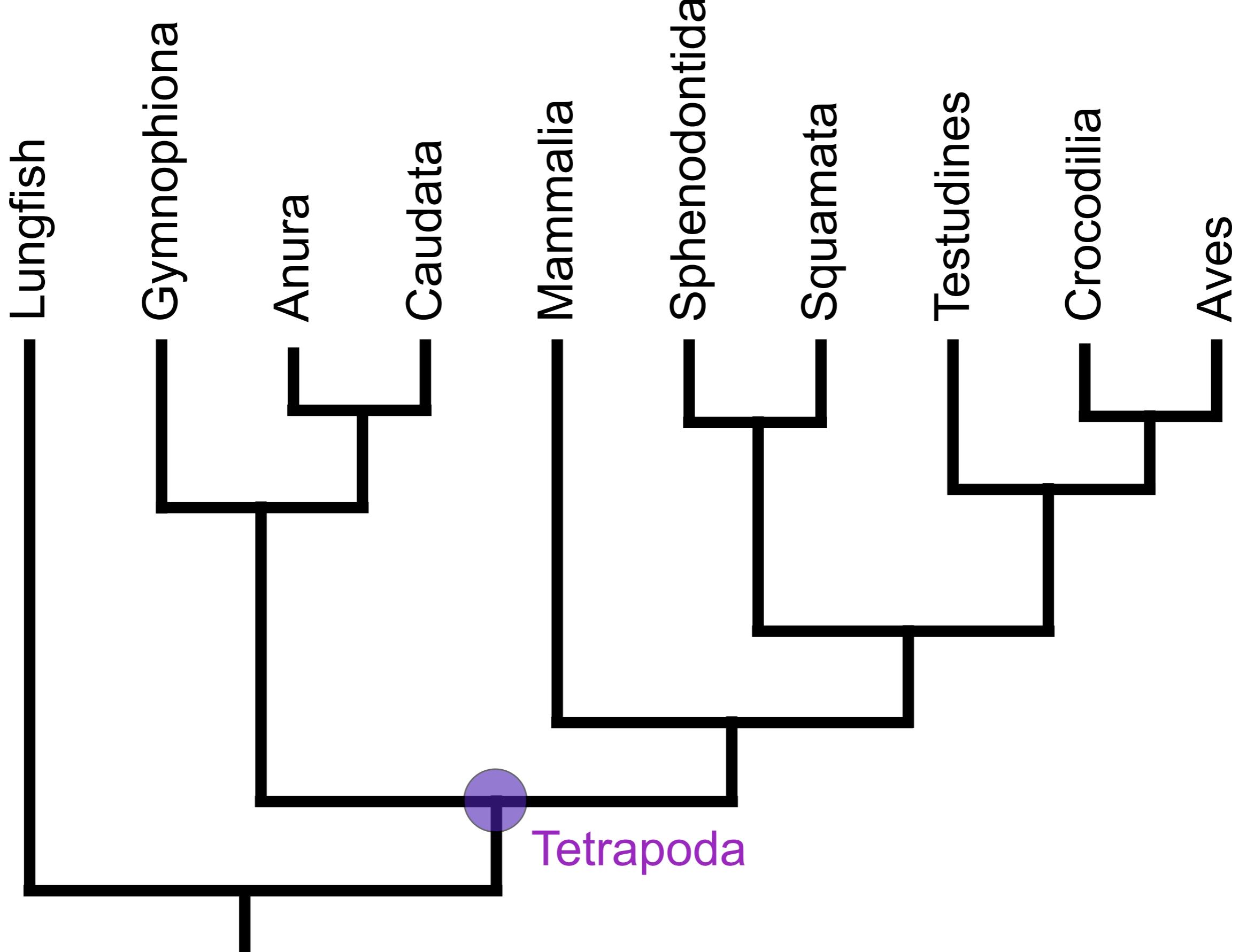


pbs.com

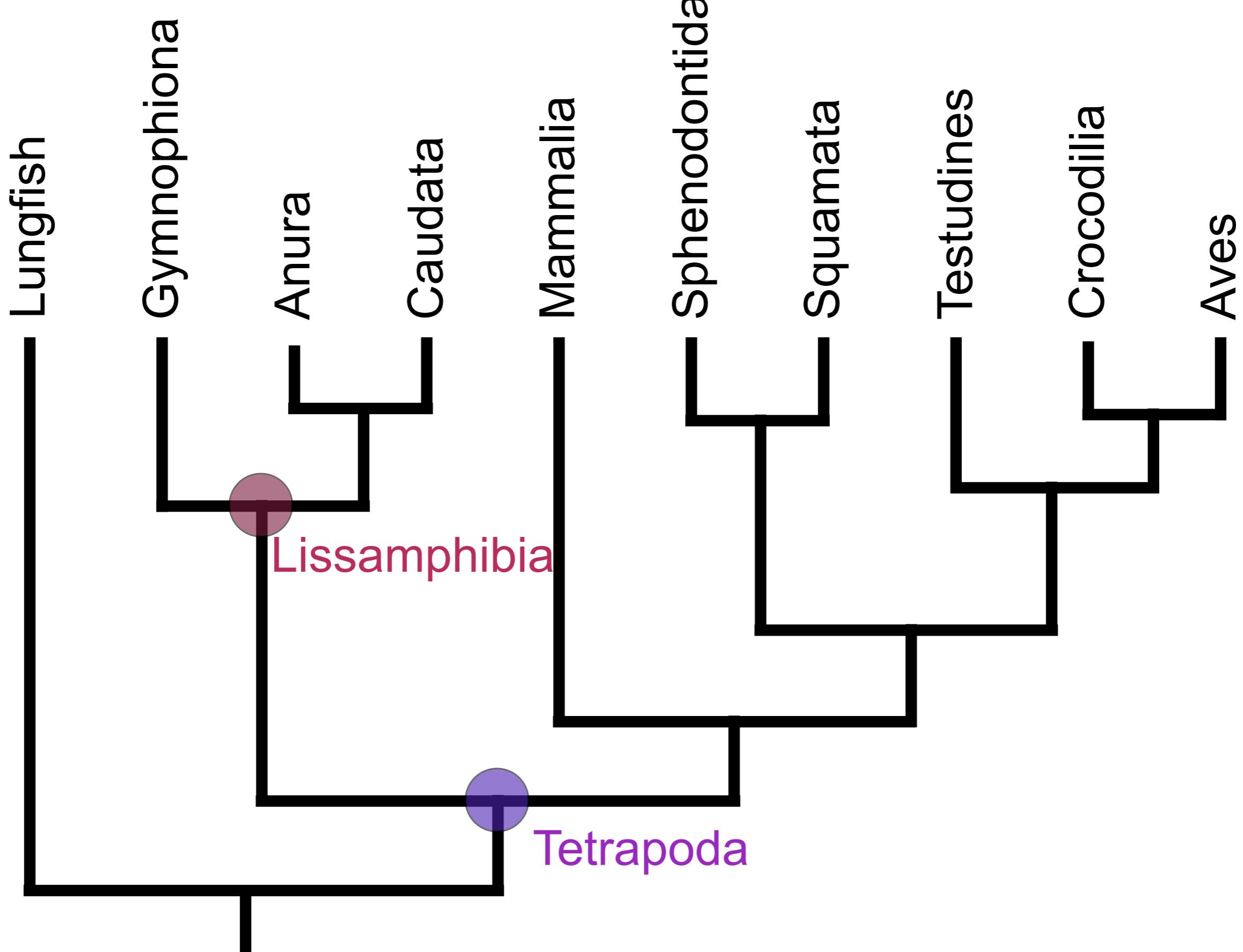
# Systematics of living “herps”



# Systematics of living “herps”

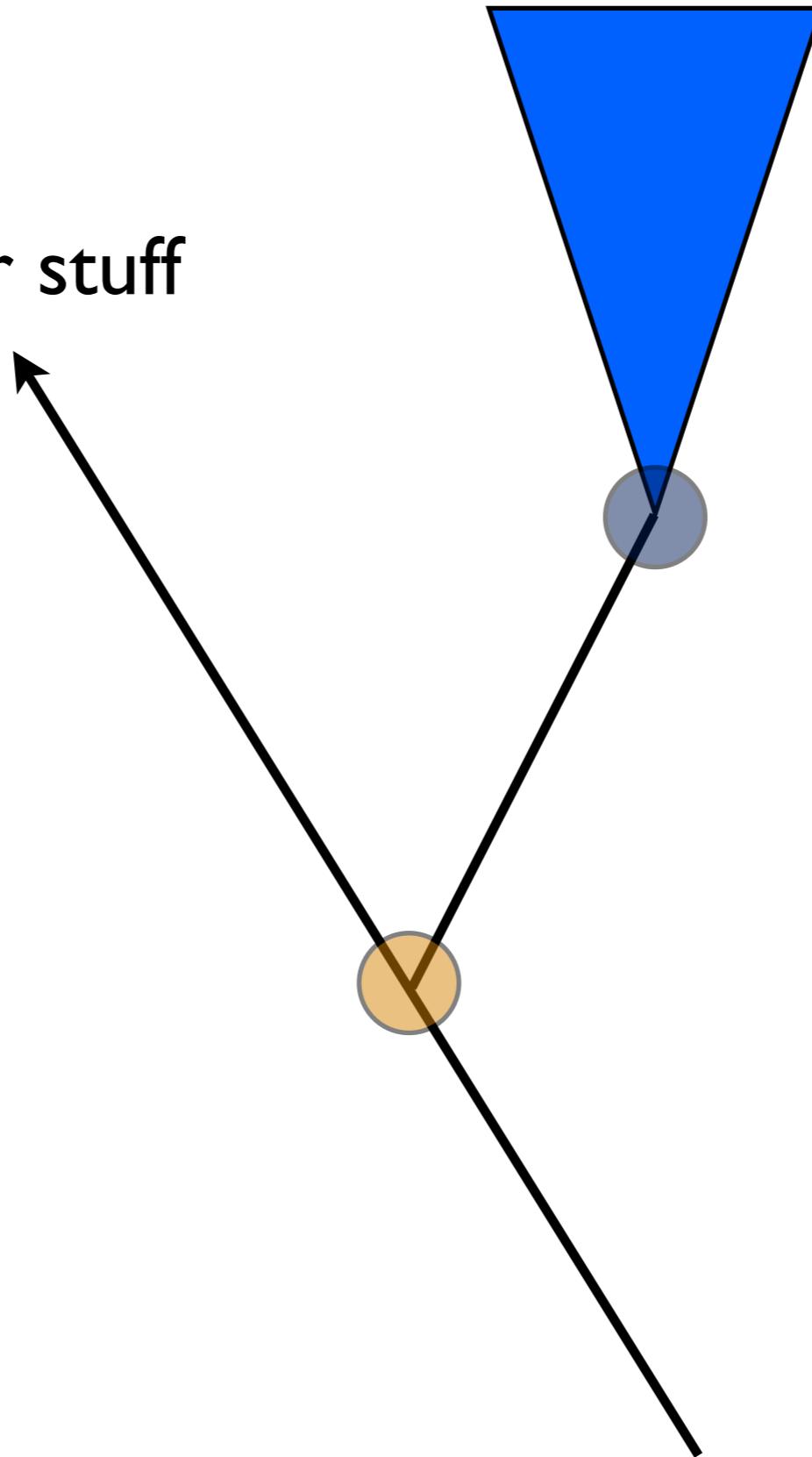


# Systematics of living “herps”



living  
amphibians

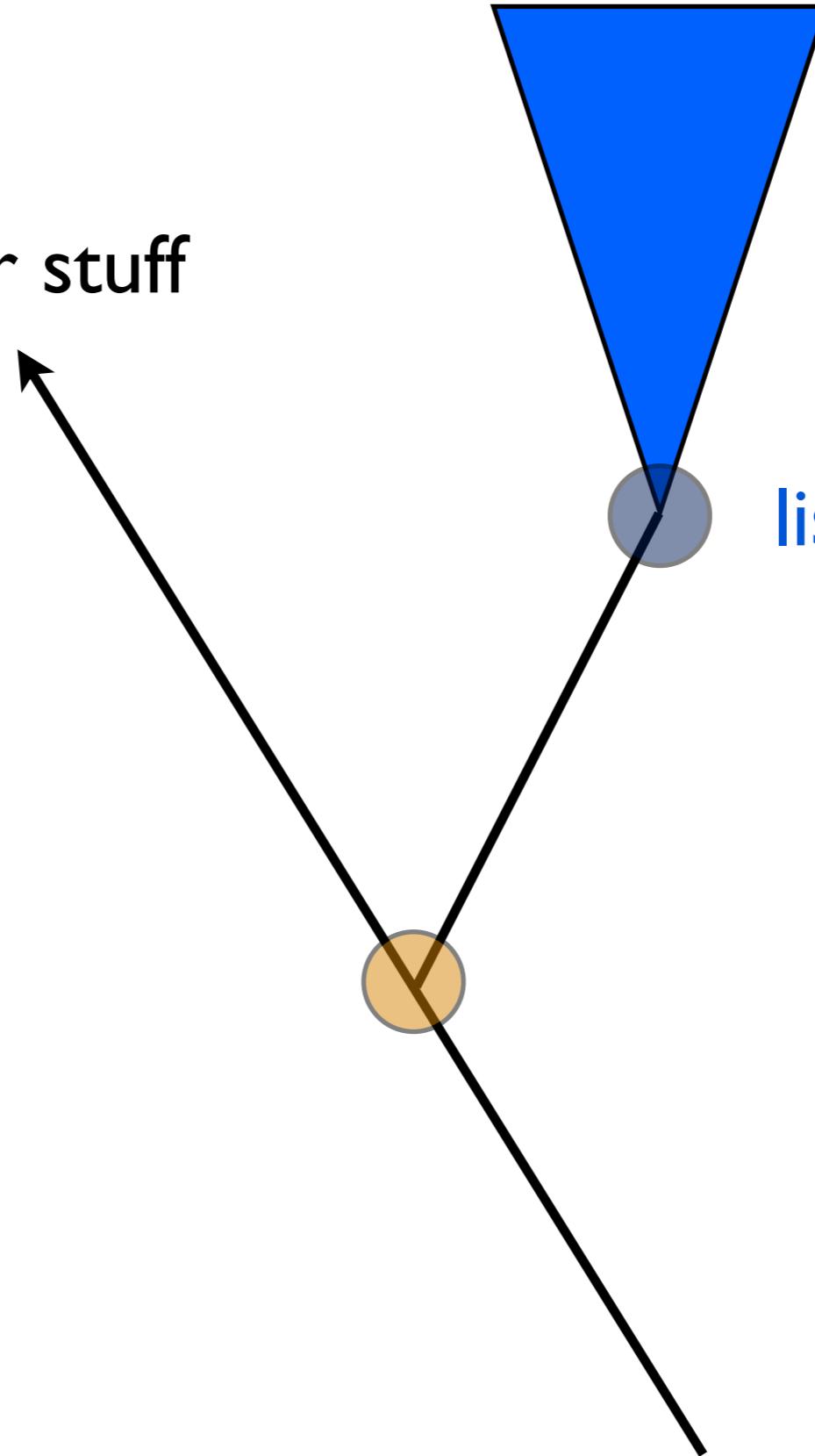
other stuff



living  
amphibians

other stuff

*lissamphibia*

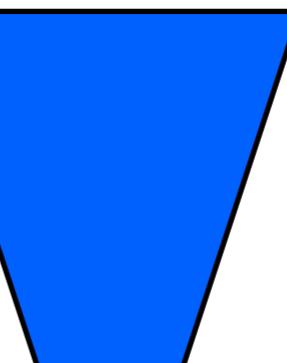


living  
amphibians

other stuff



amphibia



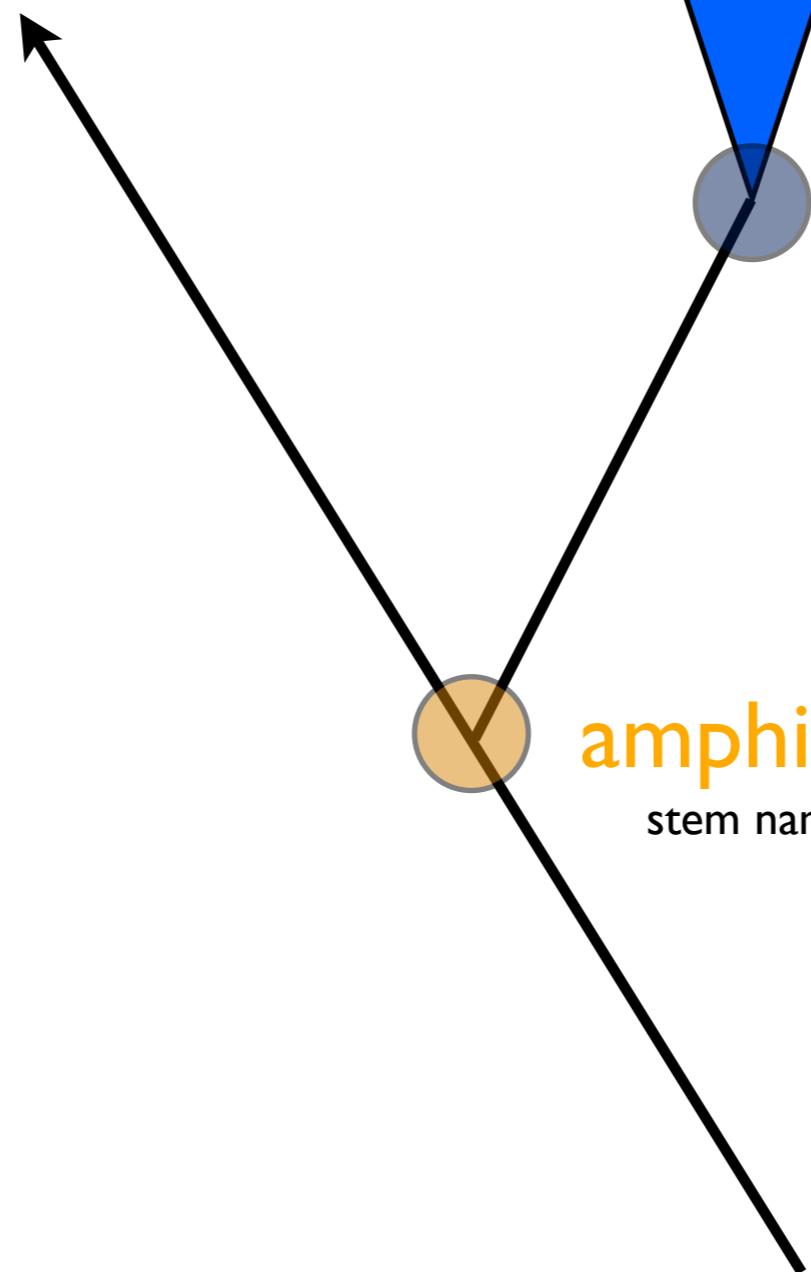
lissamphibia

living  
amphibians

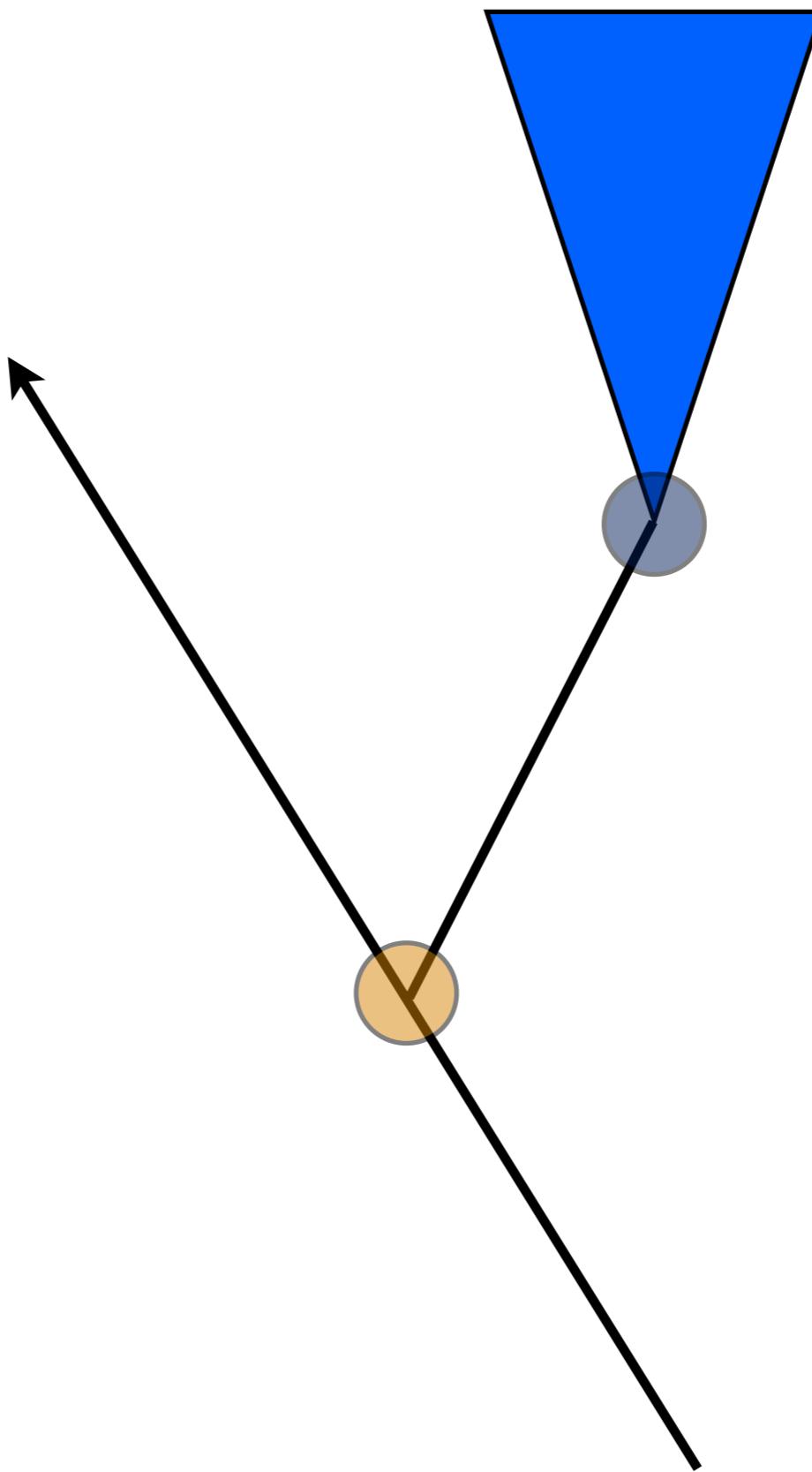
other stuff

**lissamphibia**  
node name

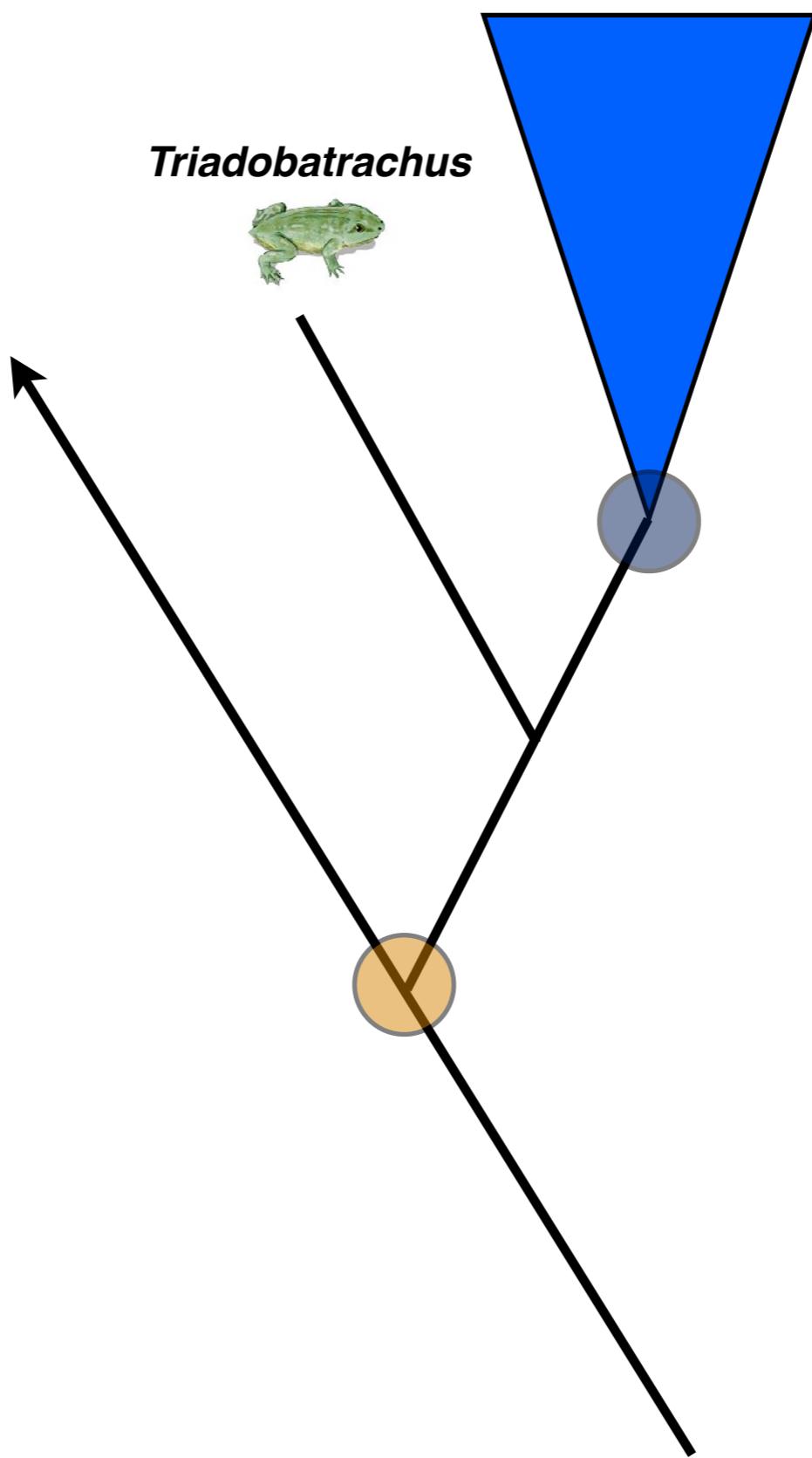
**amphibia**  
stem name



living  
amphibians

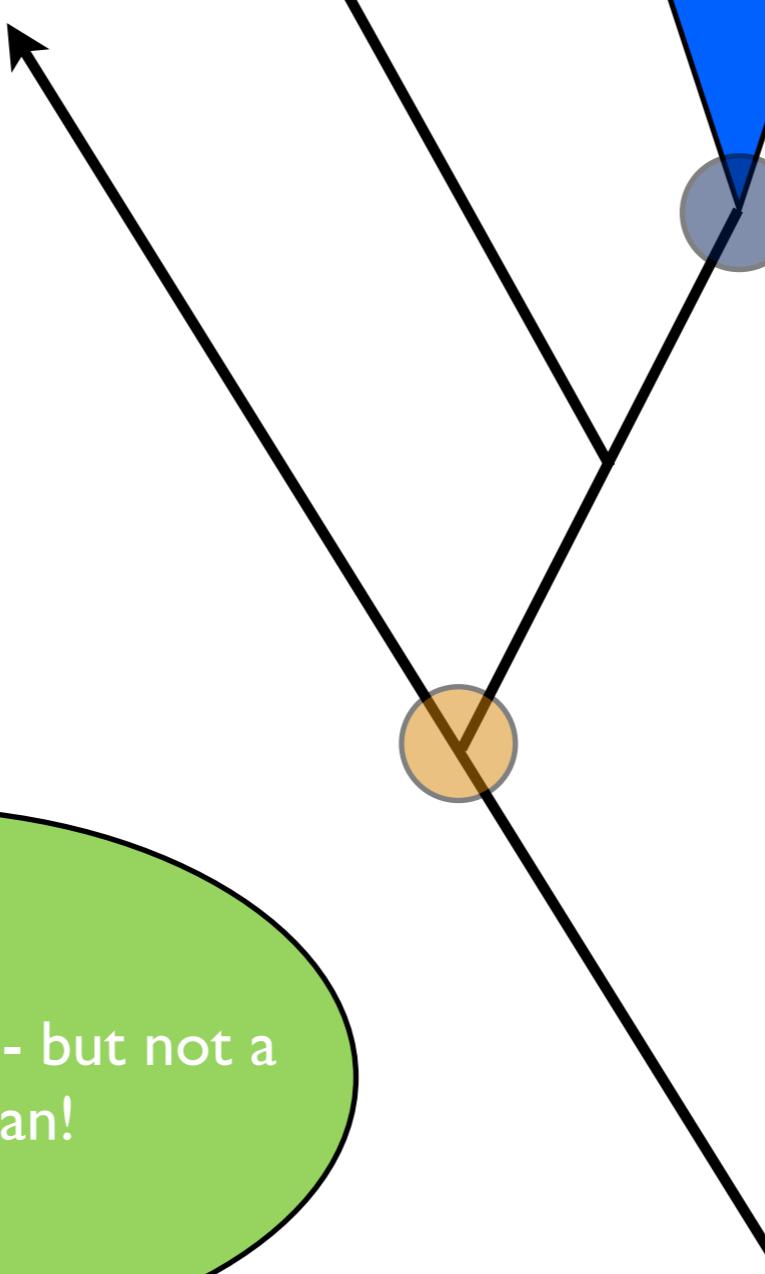
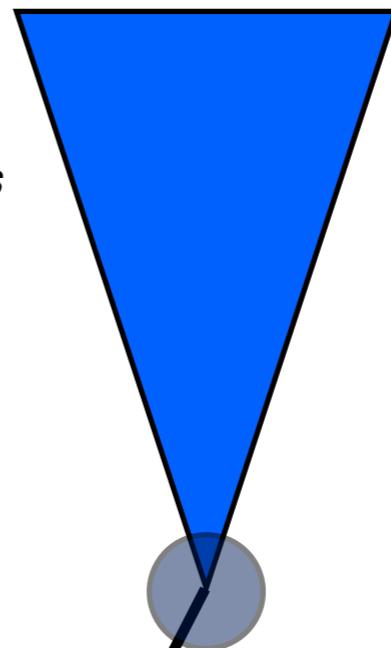


# living amphibians

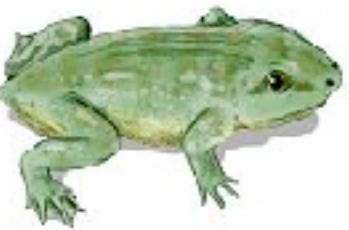


# living amphibians

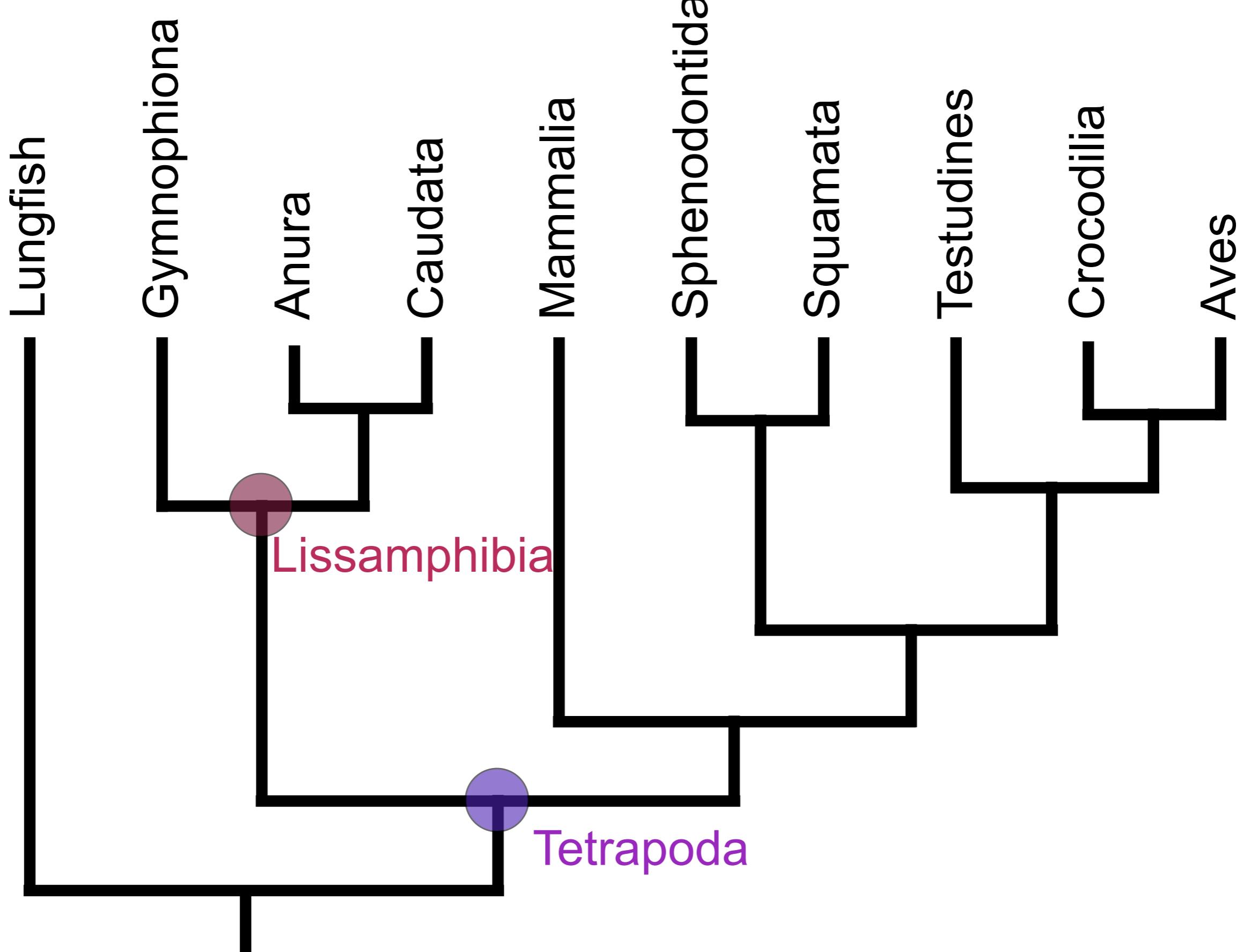
*Triadobatrachus*



I am an amphibian - but not a  
lissamphibian!



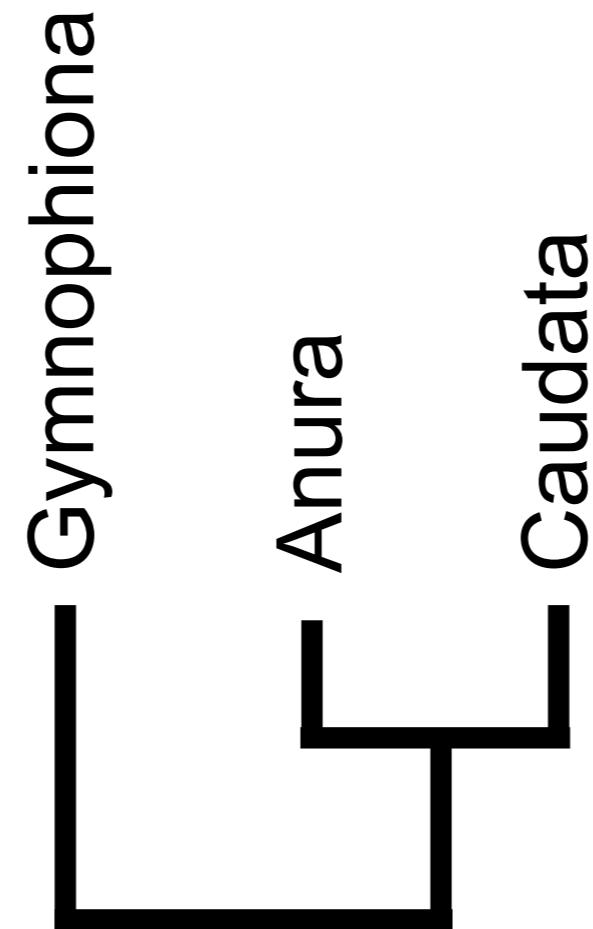
# Systematics of living “herps”



# Lissamphibia

- Caecilians + frogs + salamanders
- Living lissamphibia are monophyletic

# The living amphibians



# Gymnophiona

- Caecilians, ~186 species
- Gymnophiona = “naked snake”
- Tropical, except Madagascar and Australia



# Anura

- Frogs
- About 5000 species
- Very wide distribution,  
huge range of habitats
- Stout body, protruding  
eyes, no tail

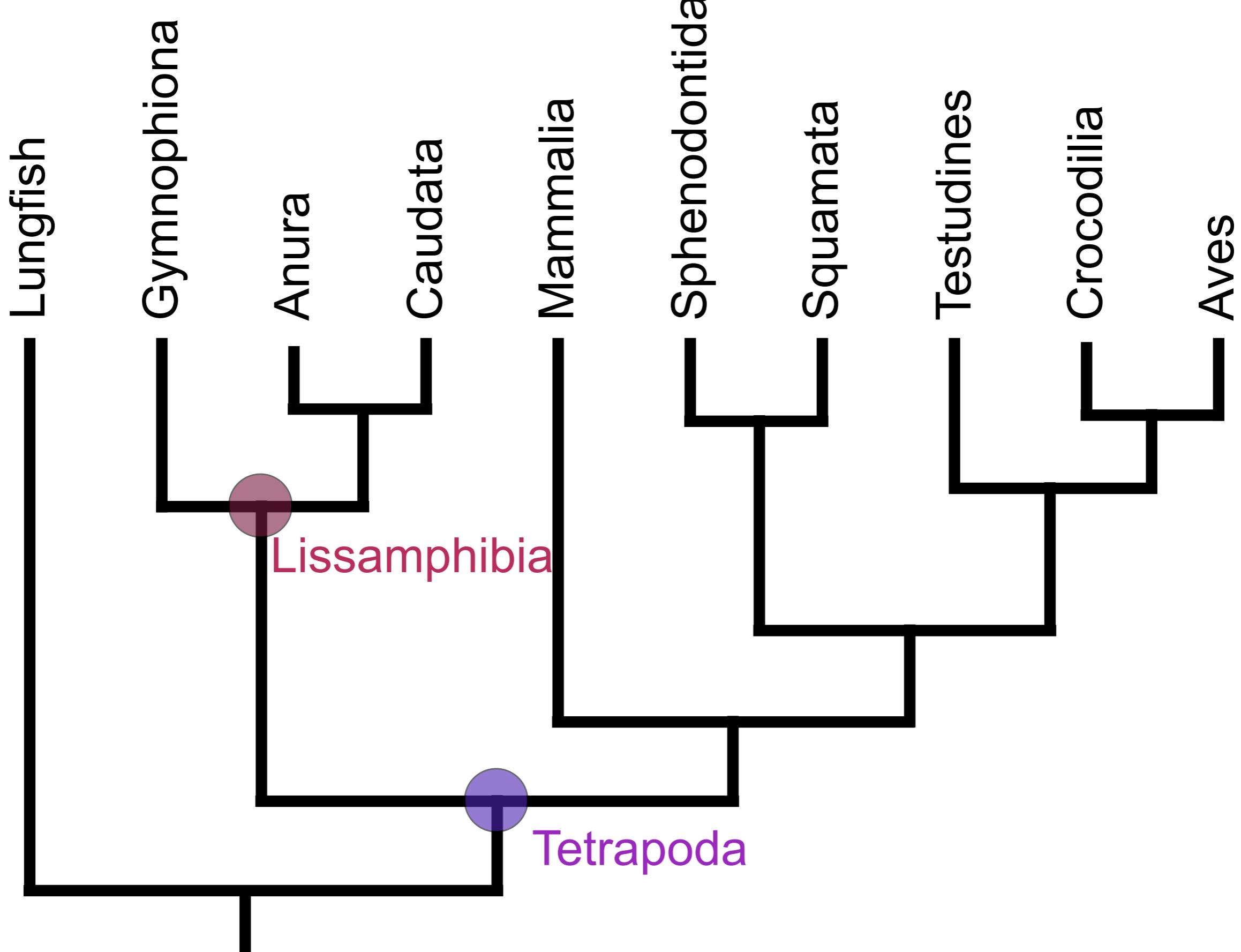


# Caudata

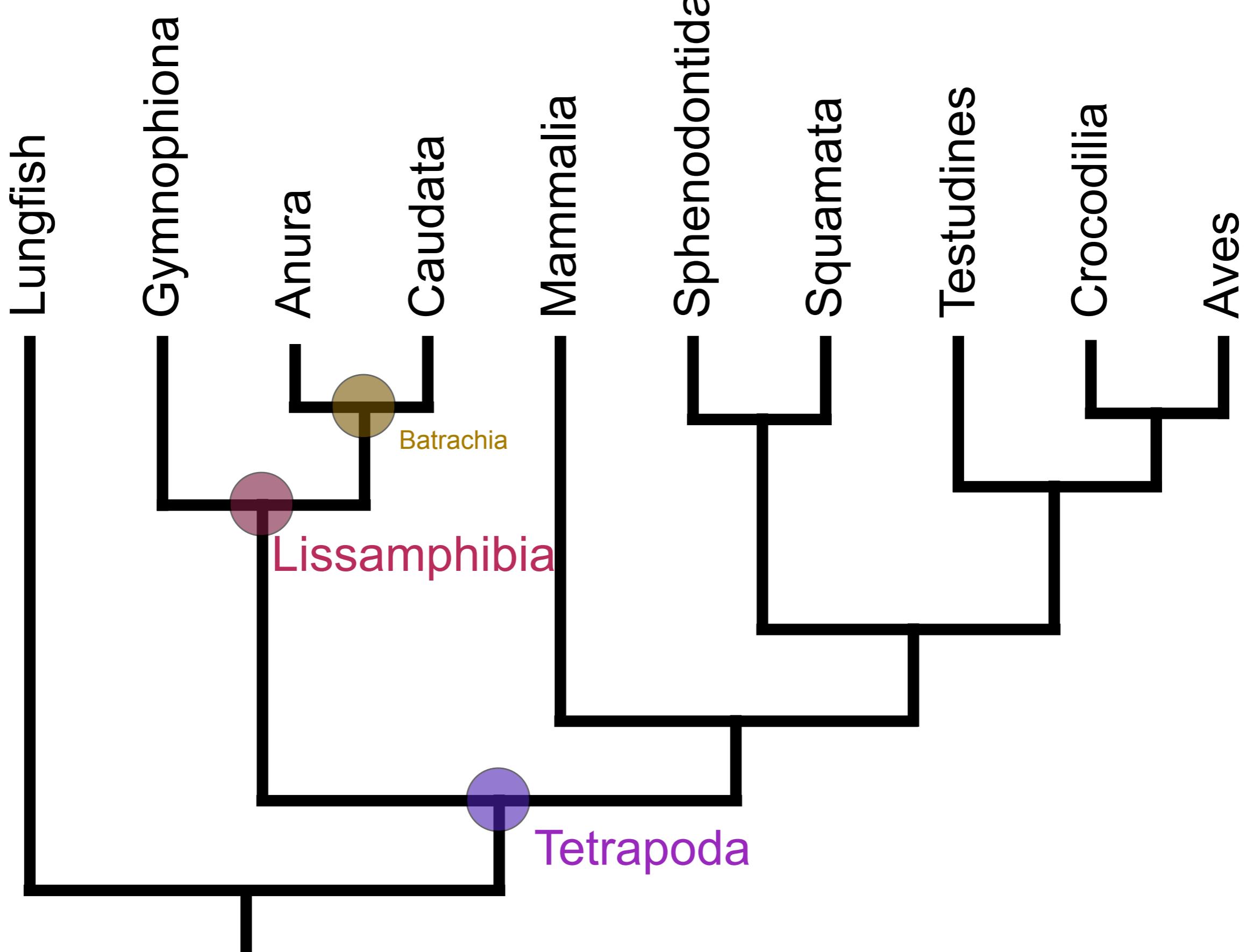
- Salamanders
- About 550 species
- Aquatic or terrestrial, usually found near water



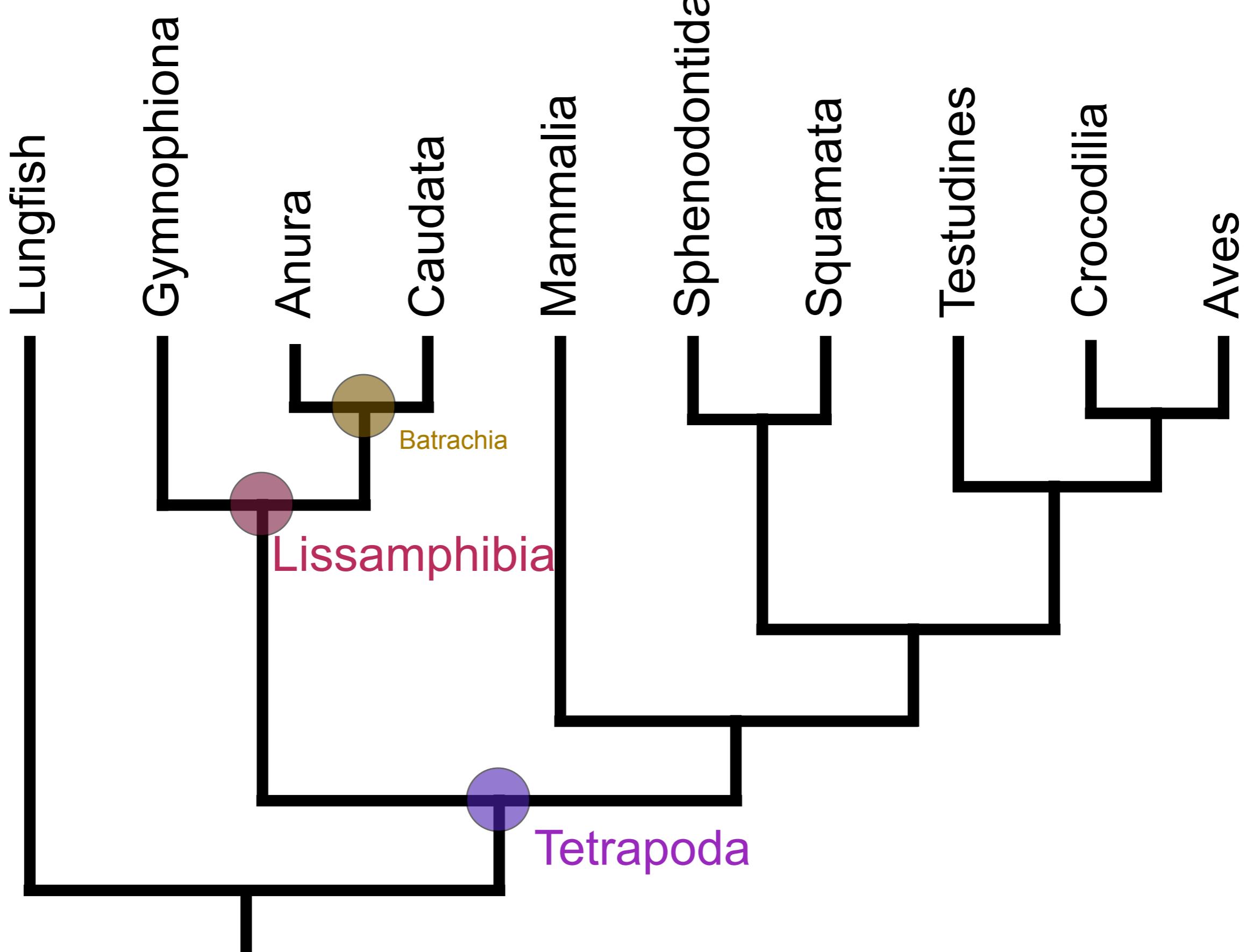
# Systematics of living “herps”



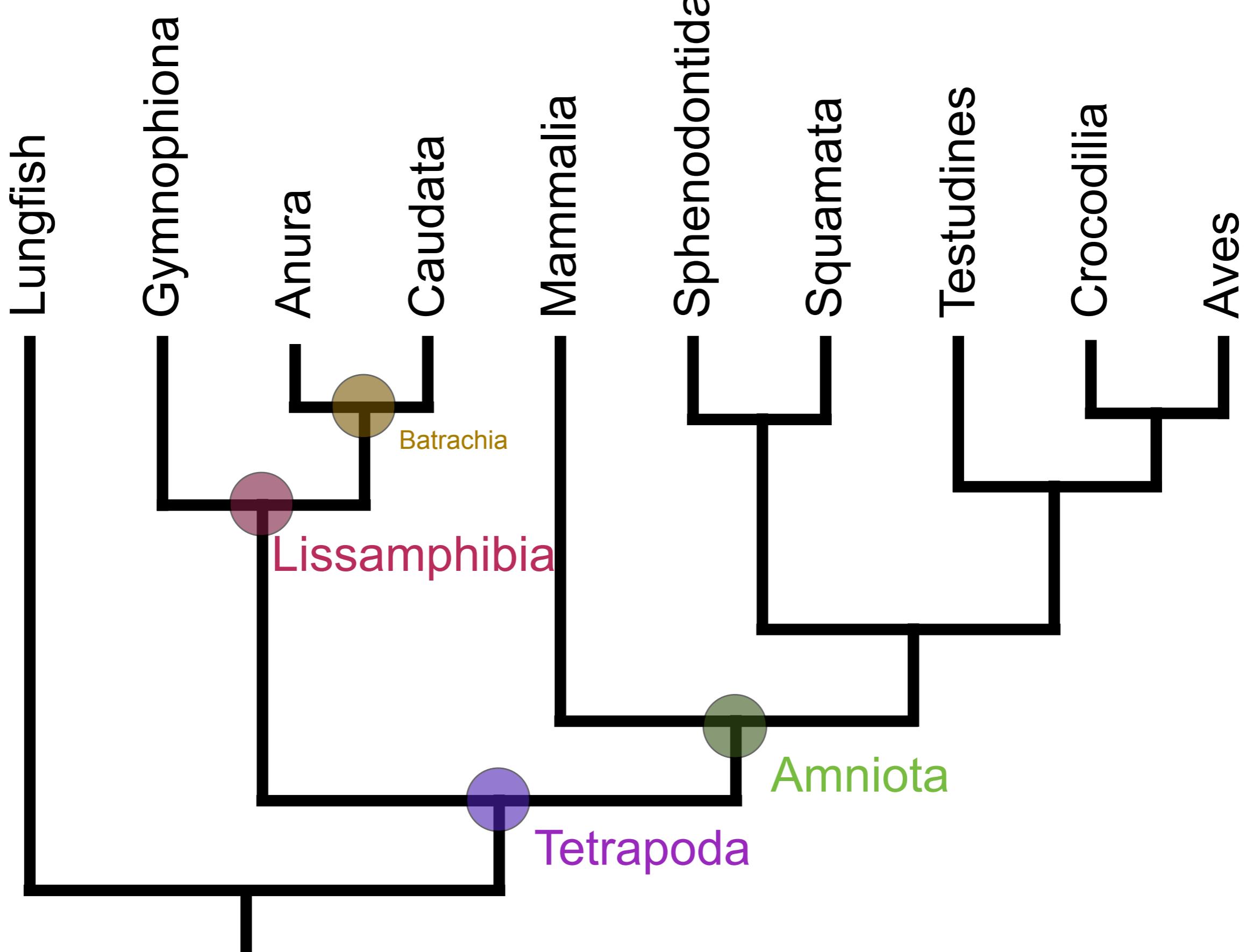
# Systematics of living “herps”



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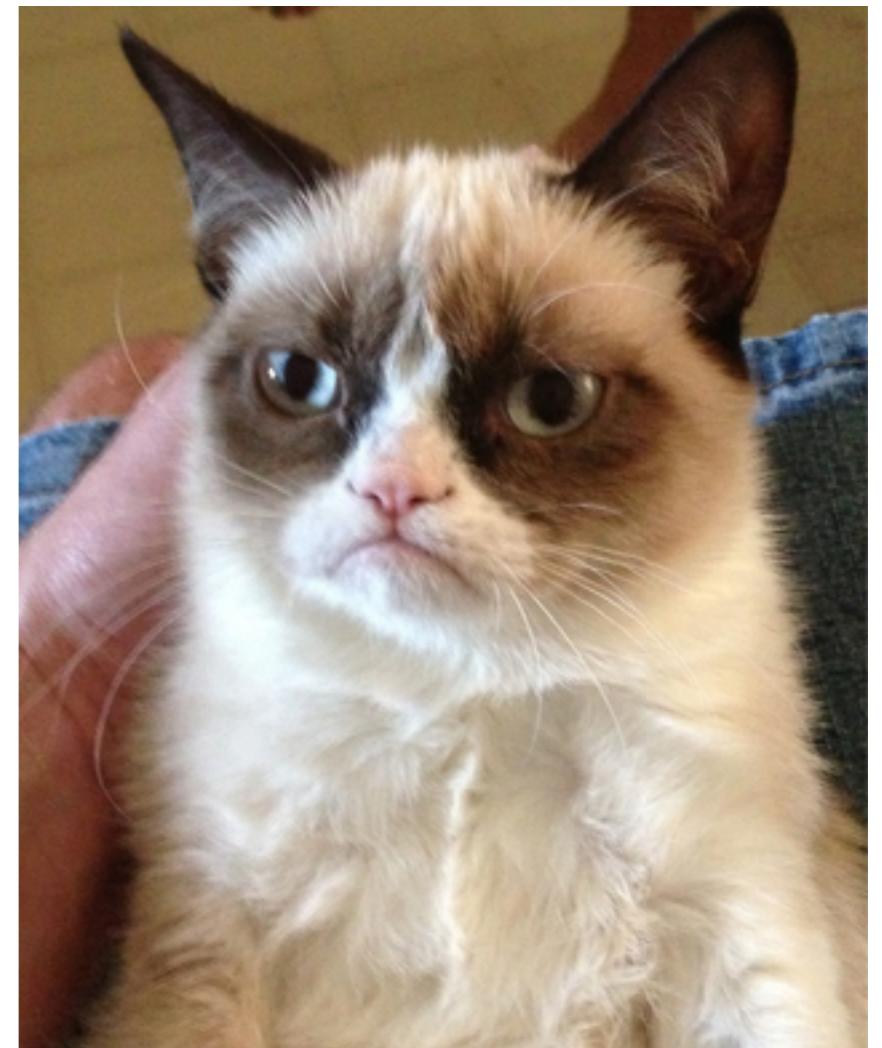


# Systematics of living “herps”

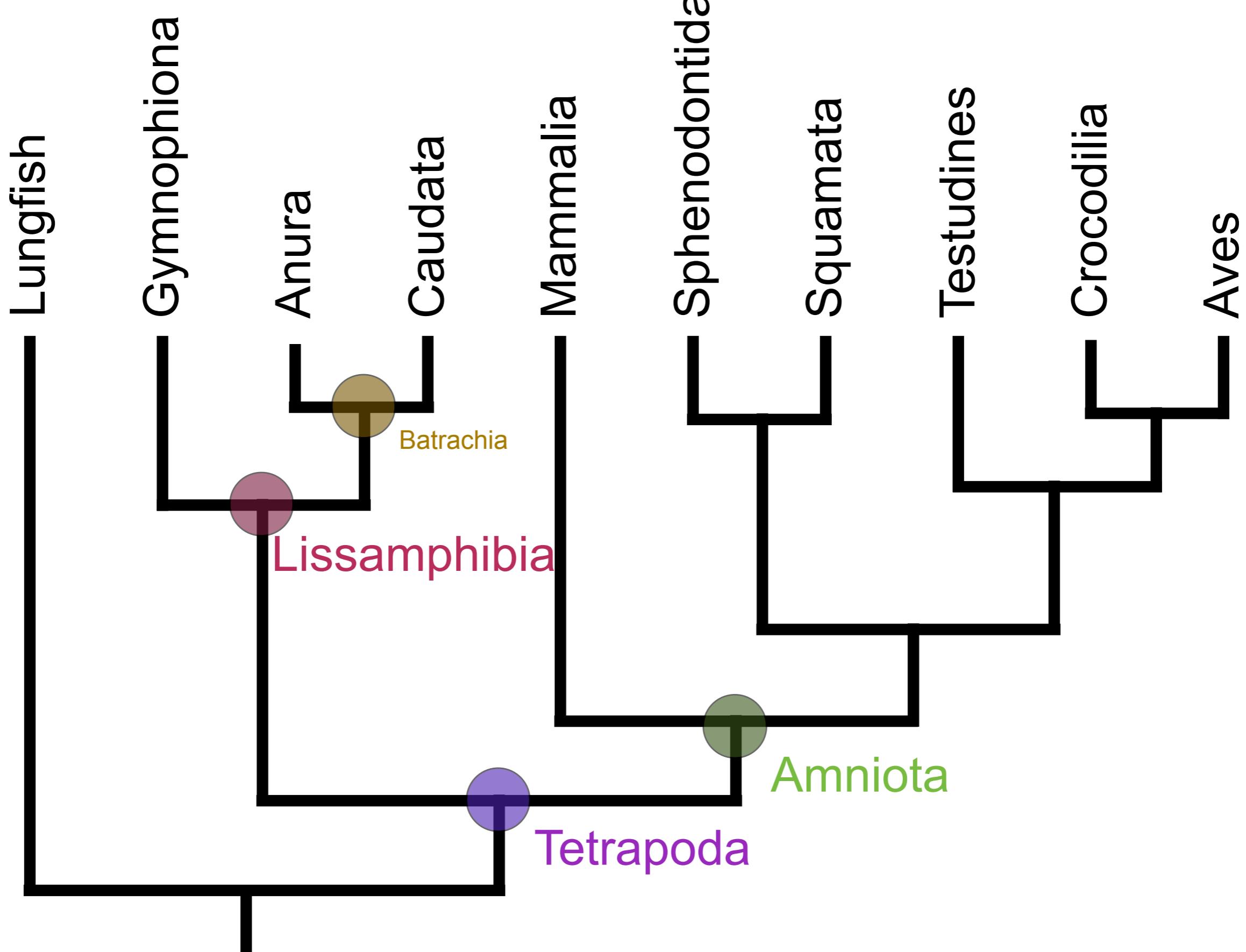


# Amniota

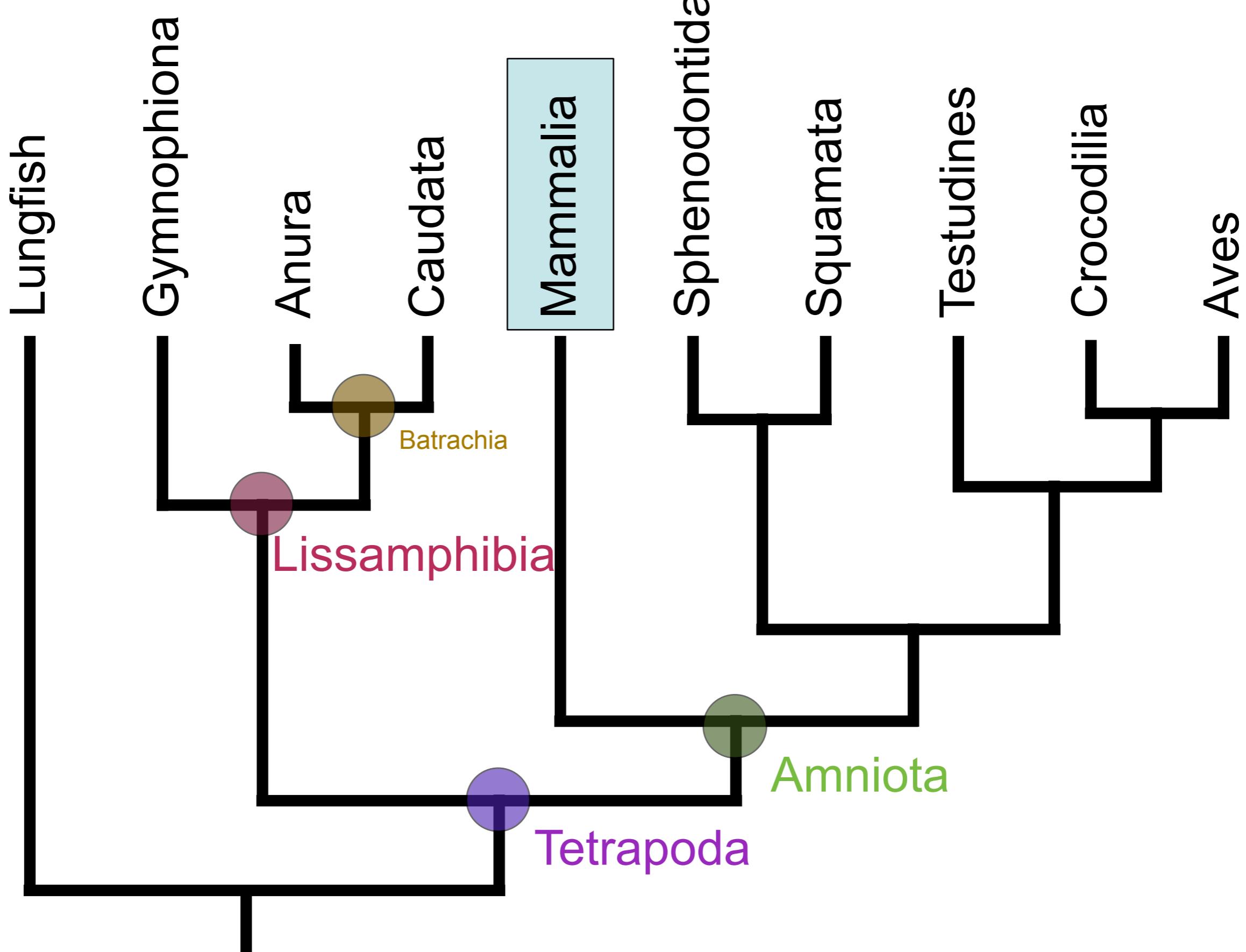
- Synapsids + sauropsids (e.g. reptiles including birds)
- Characterized by an amniotic egg
- Adaptation to life on land, free of the need to return to water



# Systematics of living “herps”



# Systematics of living “herps”



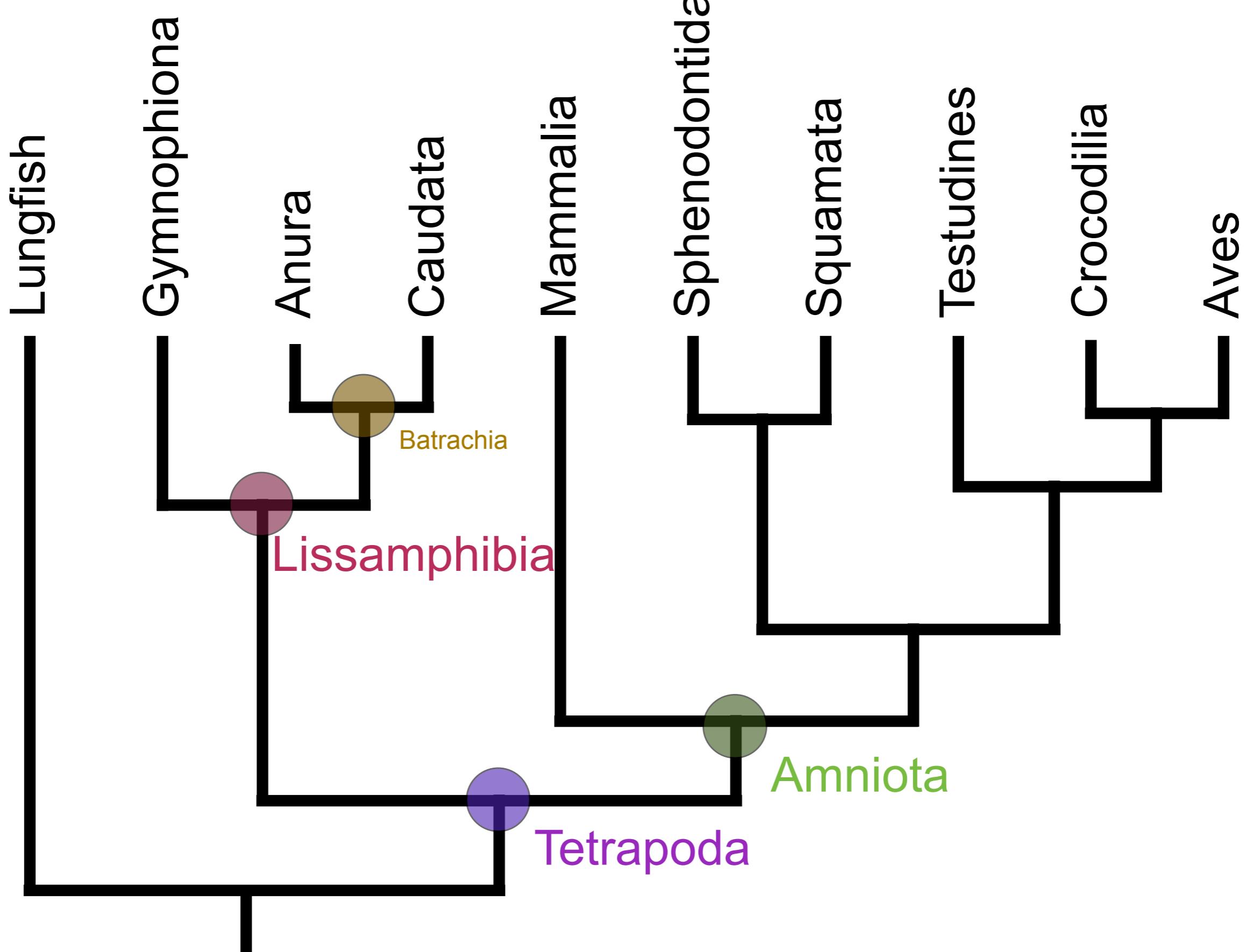
# Mammalia

- About 5400 species in 1200 genera
- Endotherms with fur, sweat glands, mammary glands, four chambered heart, etc.

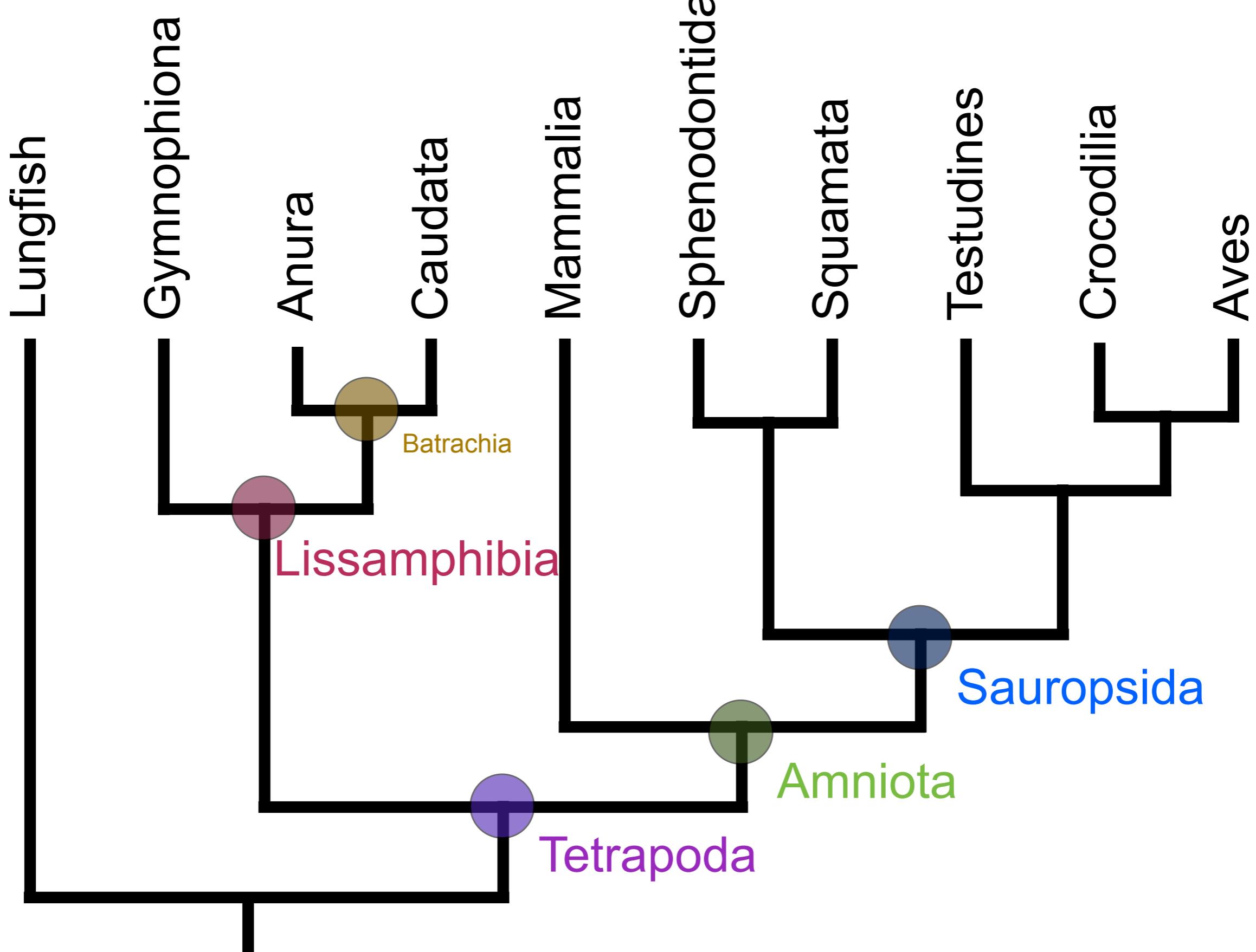


Typical mammal

# Systematics of living “herps”



# Systematics of living “herps”

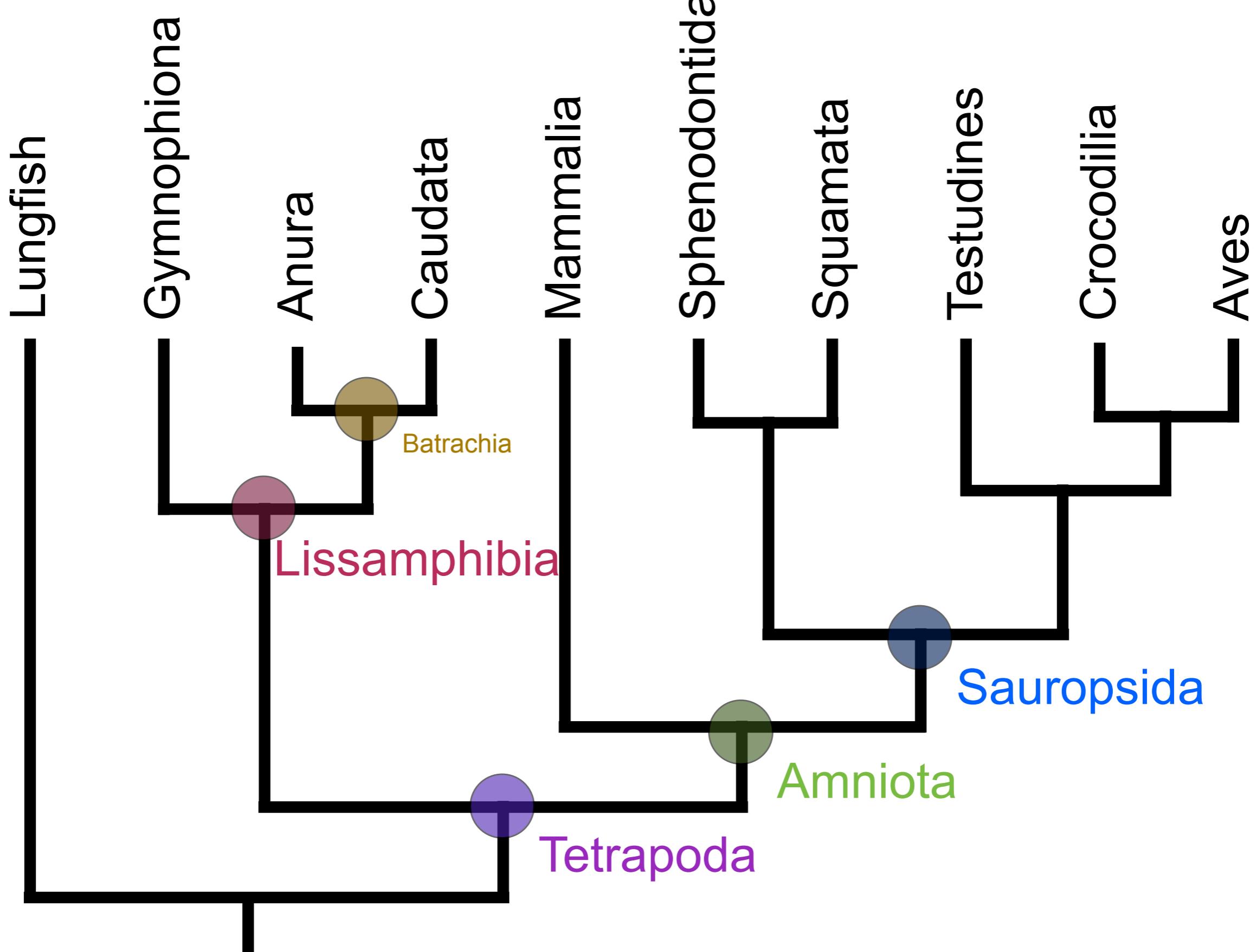


# Sauropsida

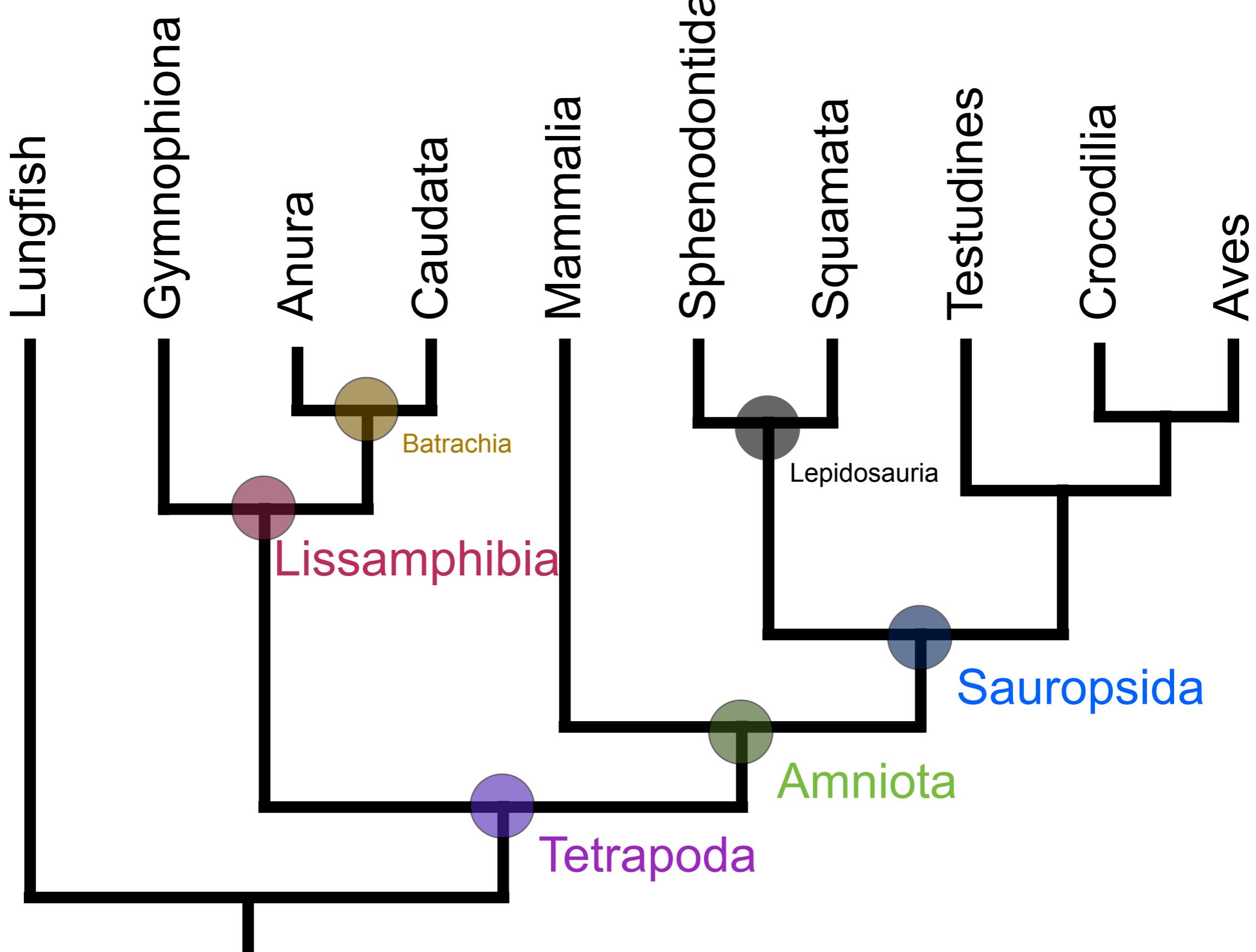
- Reptiles
- Extremely diverse group that lives in a wide variety of habitats around the world
- Includes birds and other dinosaurs



# Systematics of living “herps”



# Systematics of living “herps”

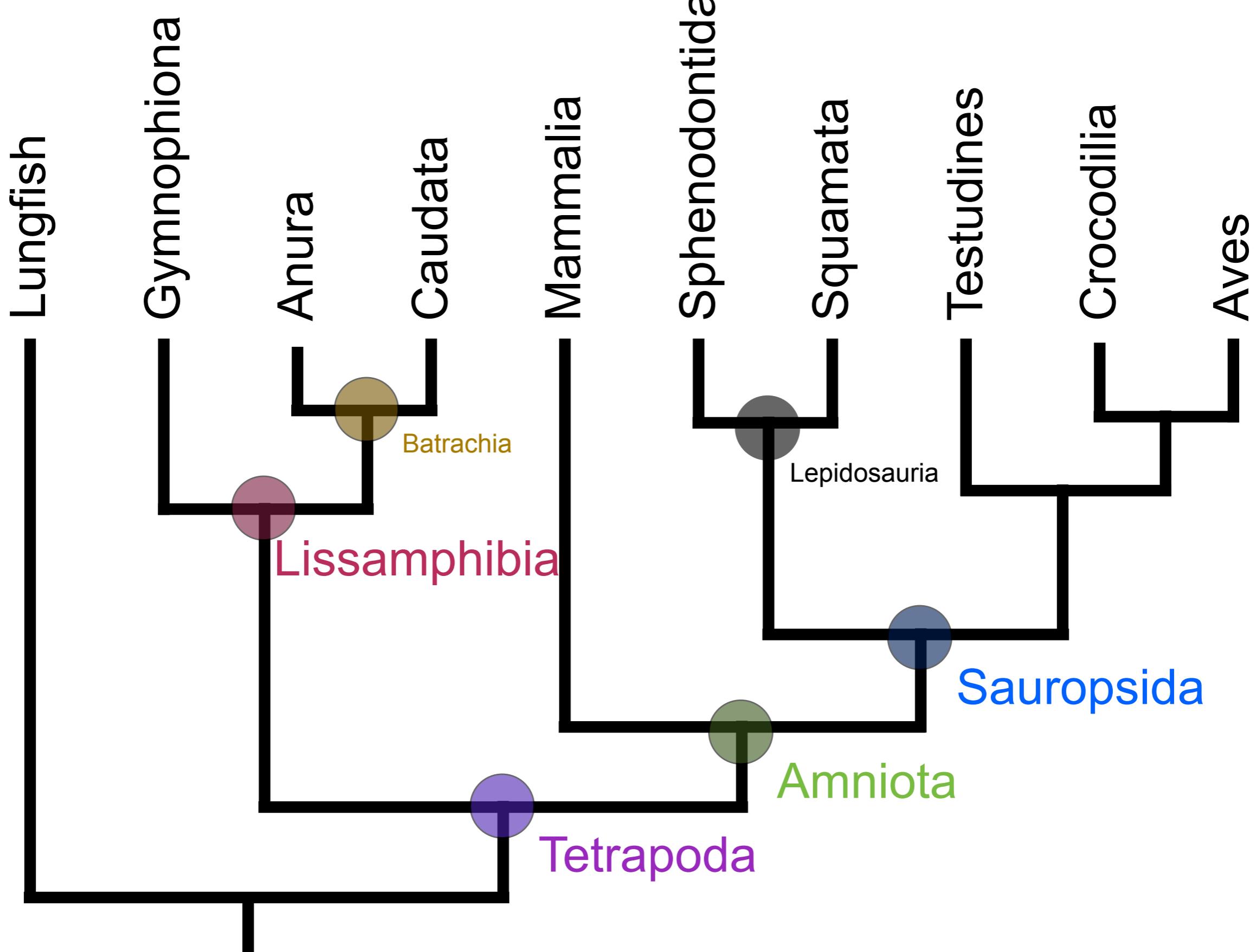


# Lepidosauria

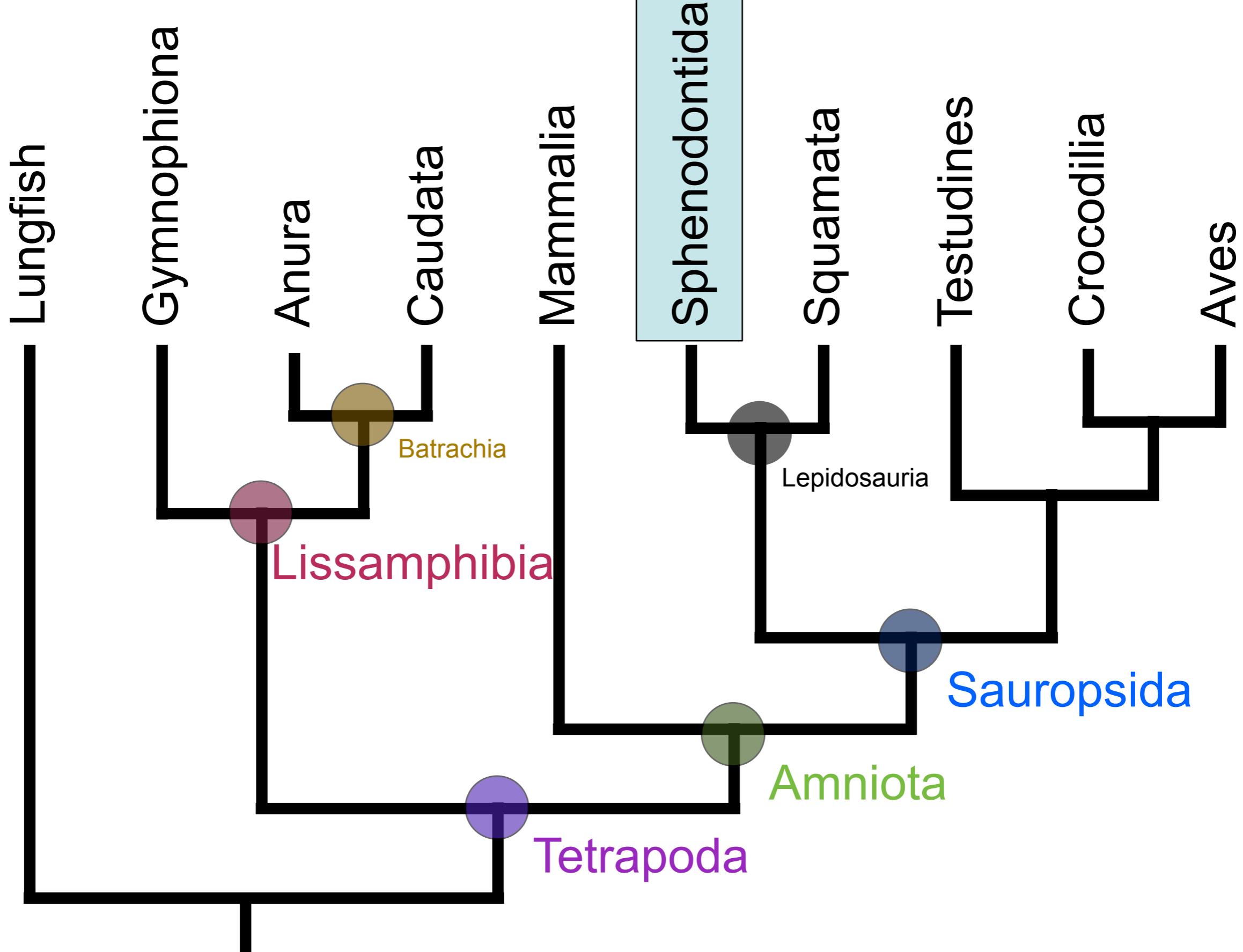
- Reptiles with overlapping scales
- Includes squamates and rhynchicephalians



# Systematics of living “herps”



# Systematics of living “herps”



# Sphenodontida

- Tuataras
- 2 species in one genus, New Zealand
- Very distinctive morphology, but lizardlike
- Terrestrial, live in burrows, tolerate cold temps
- Primarily insectivorous
- Long-lived
- Small coastal islands; Half live on Stephens Island

# Sphenodontida

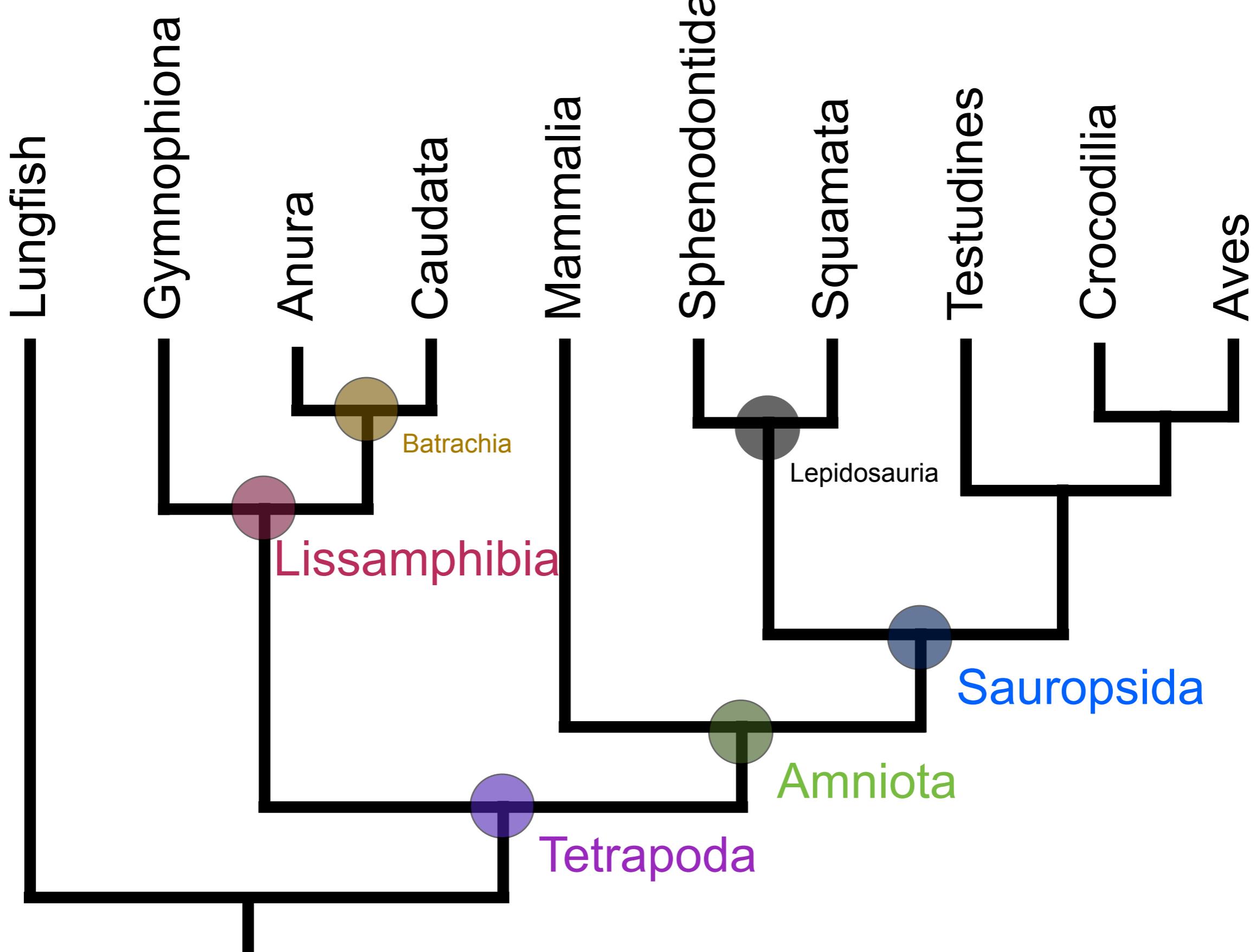


Copyright: Dept. of Conservation

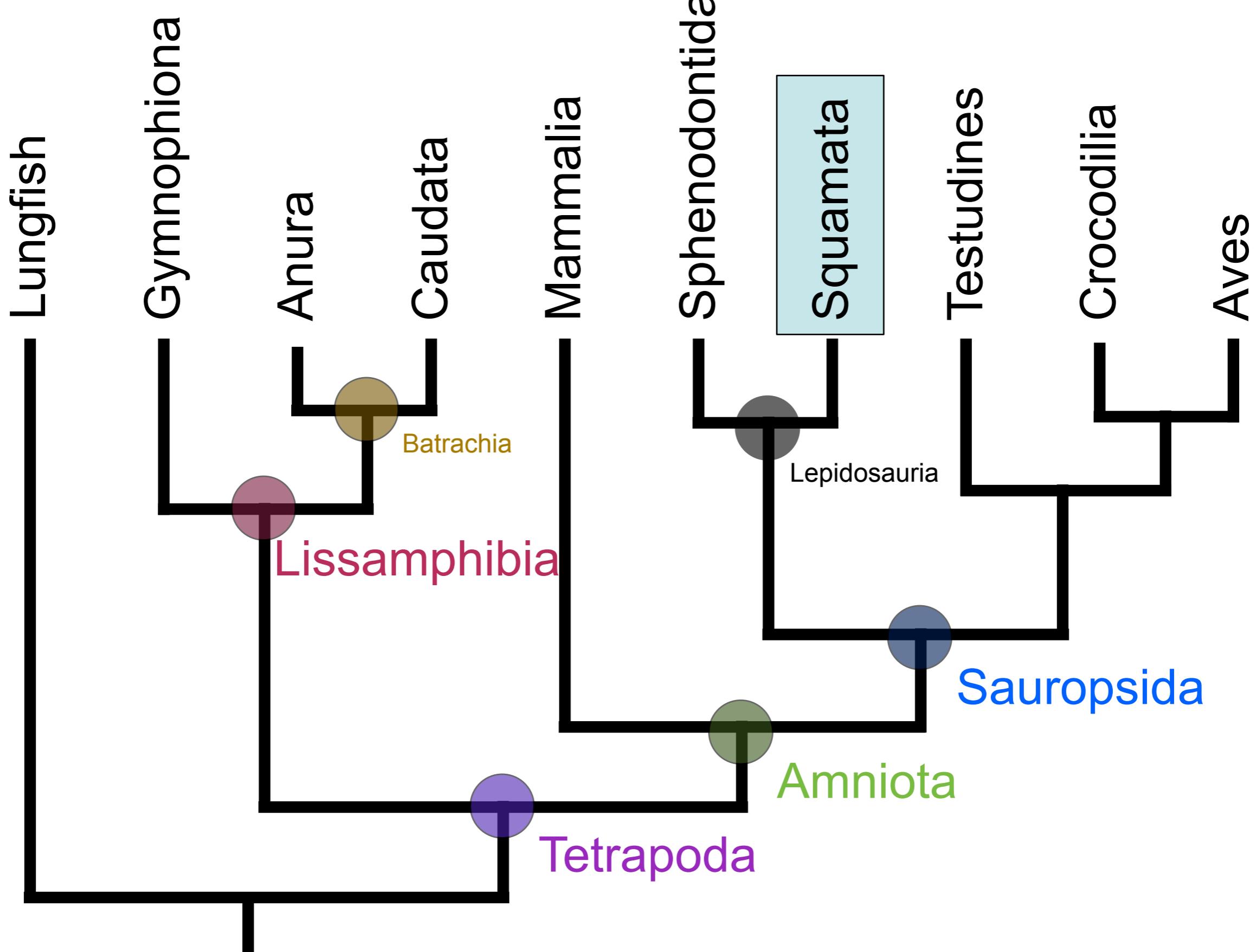


*Sphenodon punctatus*

# Systematics of living “herps”



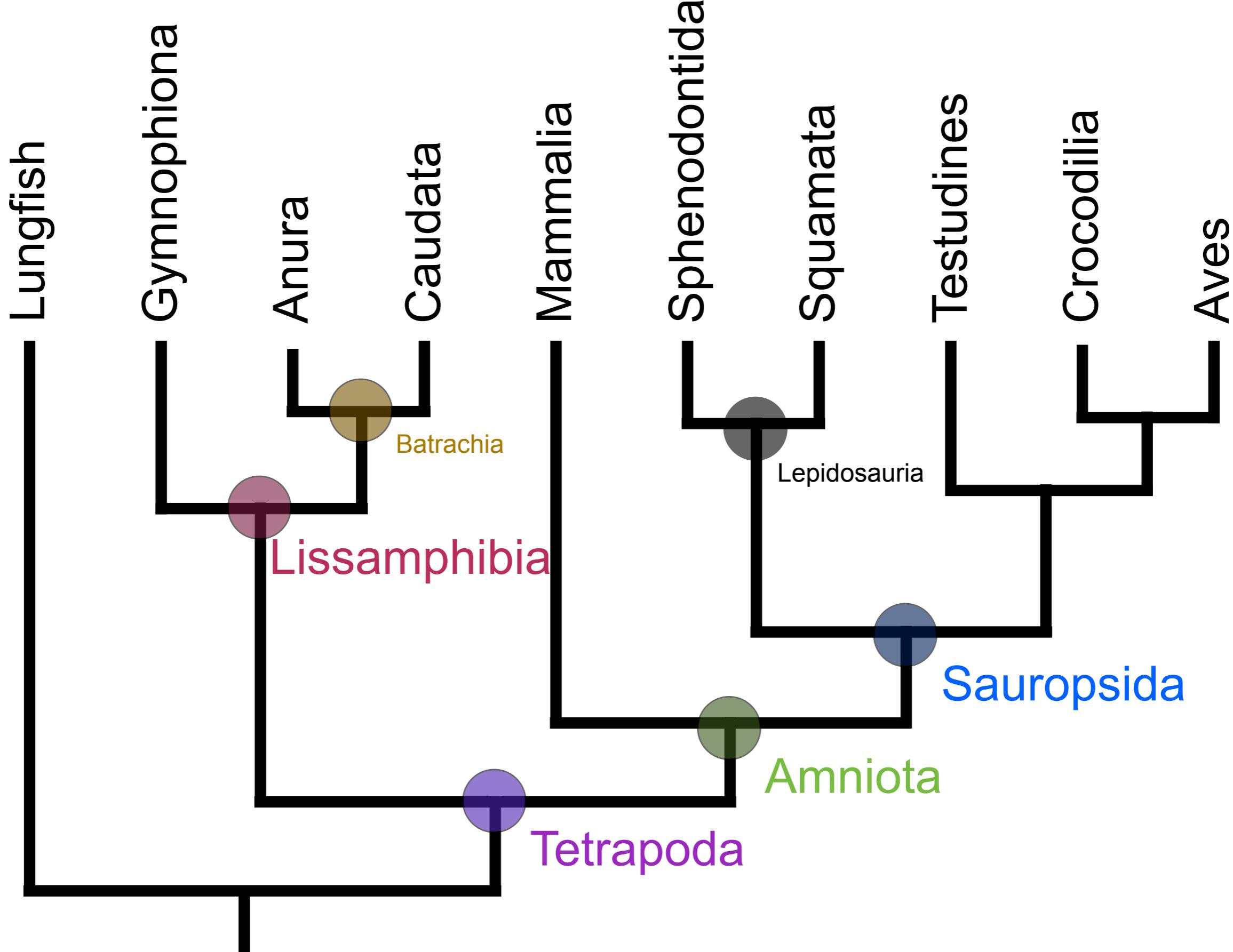
# Systematics of living “herps”



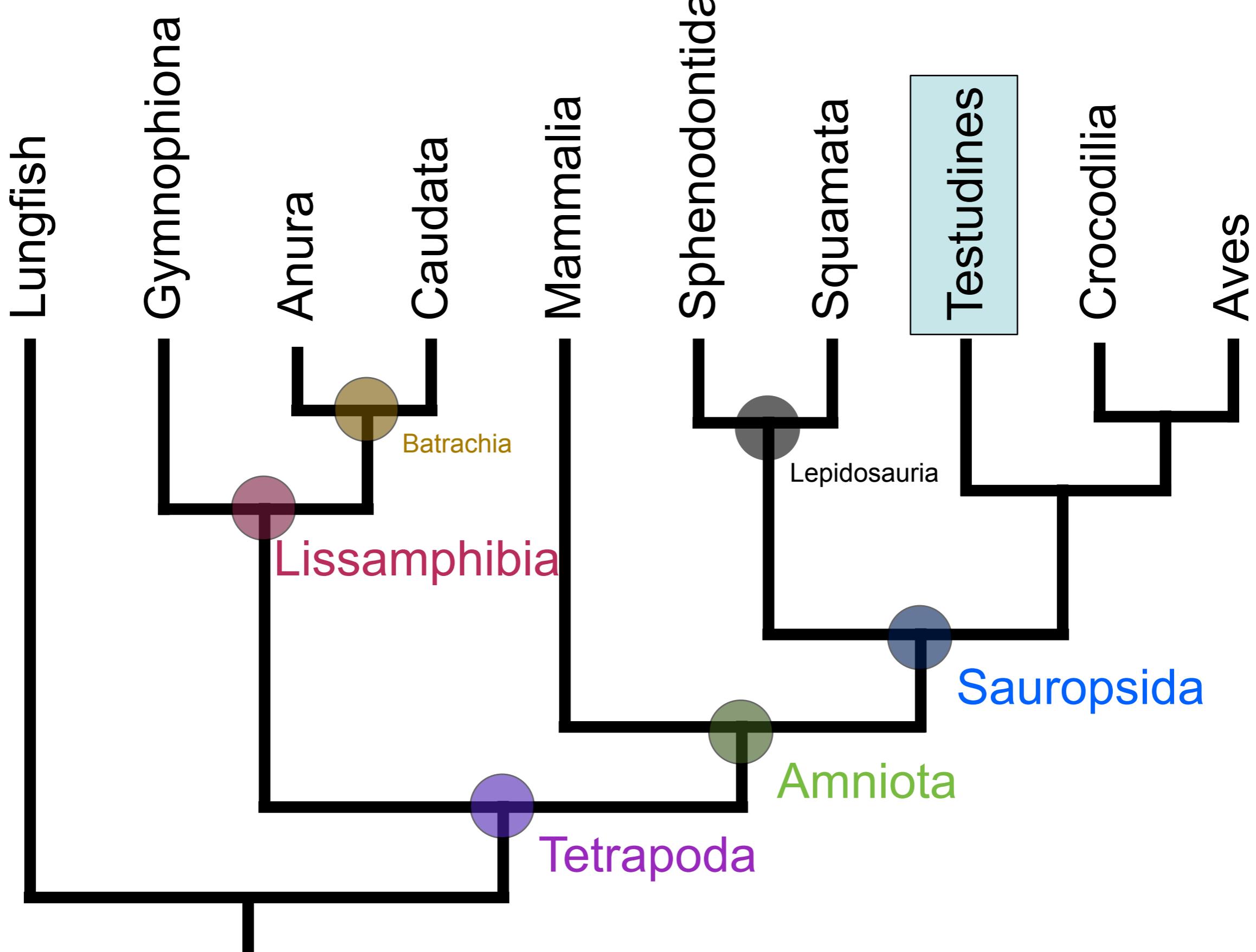
# Squamata

- Snakes and lizards
- More than 7000 species
- Large number of shared derived characters

# Systematics of living “herps”



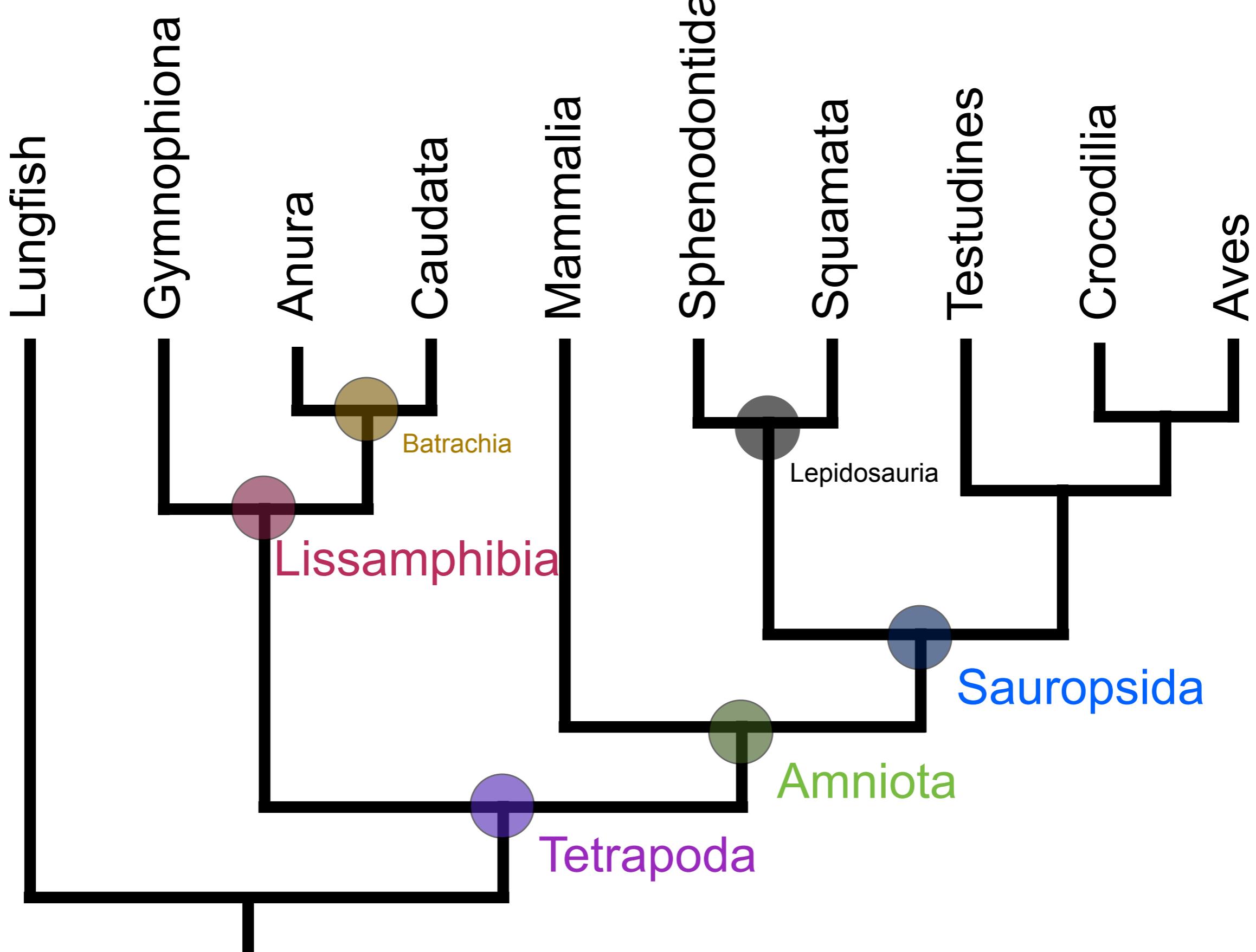
# Systematics of living “herps”



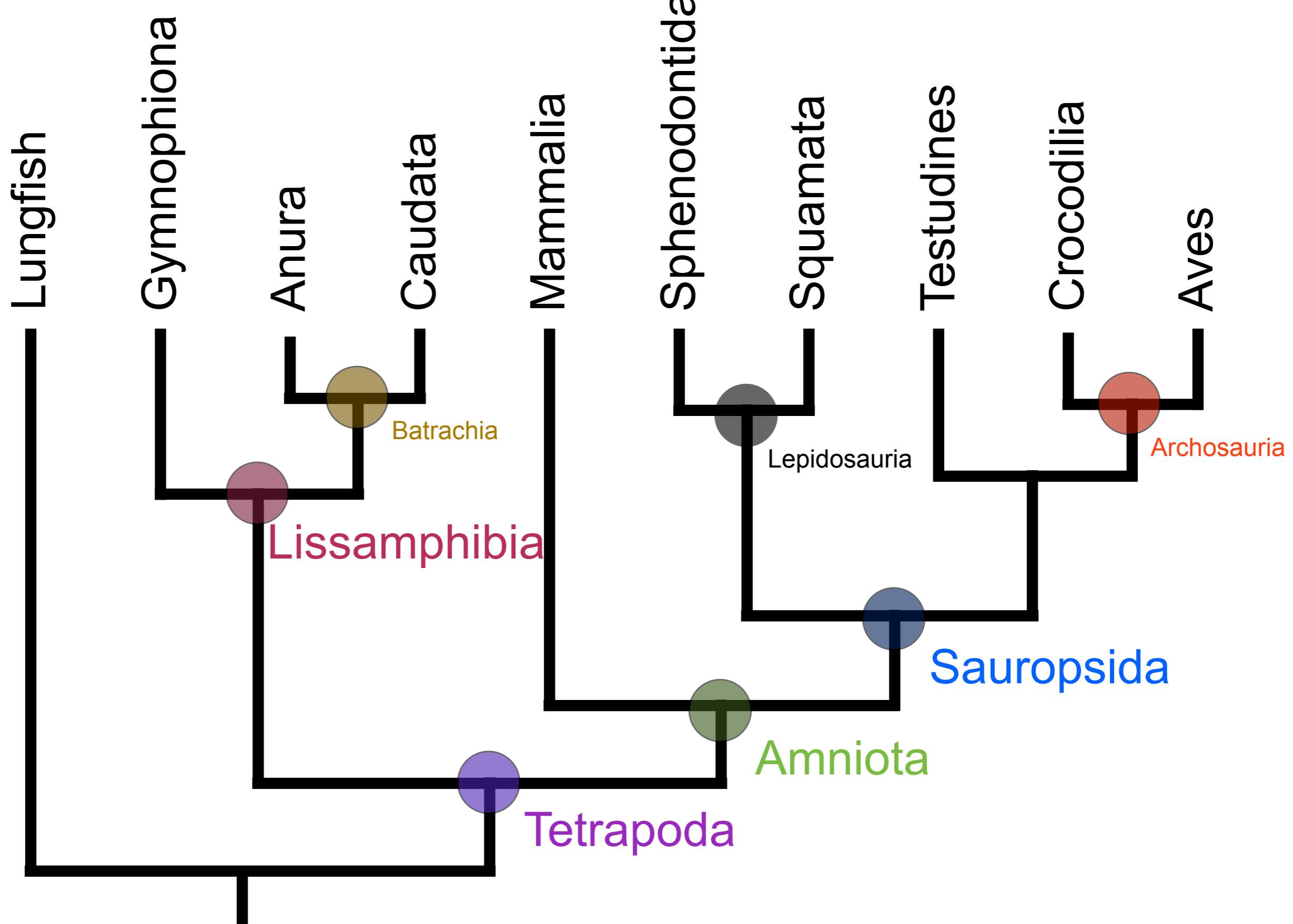
# Testudinides

- Fossils from at least 210 mya
- Anapsid skull
- Toothless jaws
- Ribs united with bony carapace (top of shell)
- Plastron - bottom of shell

# Systematics of living “herps”



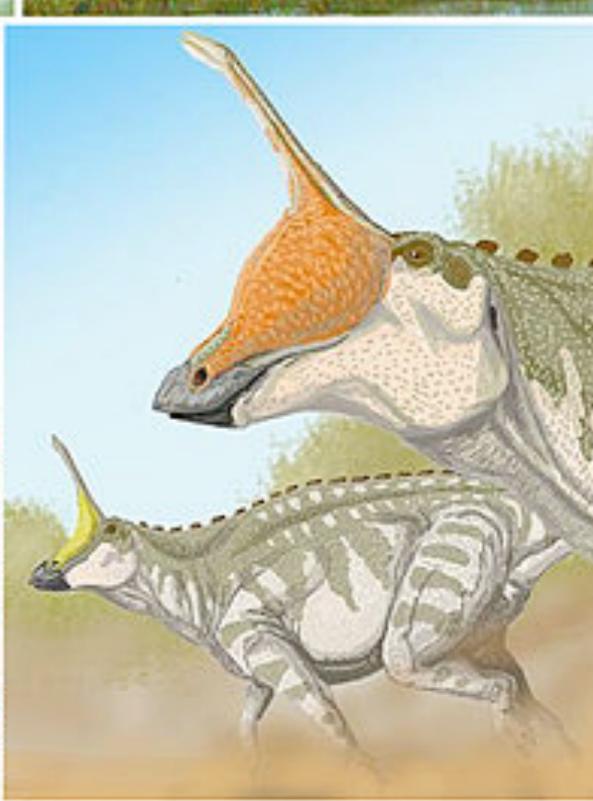
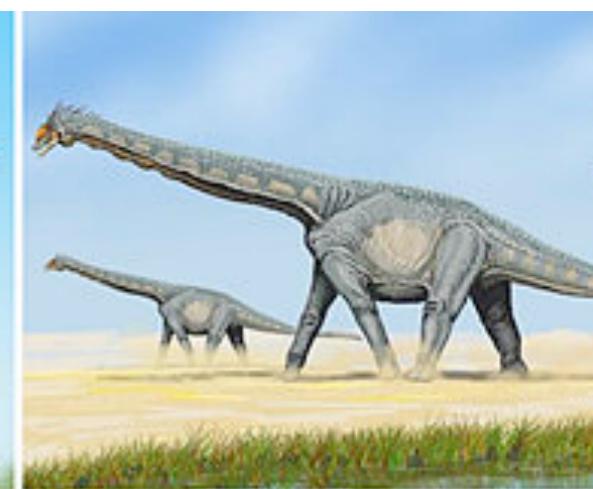
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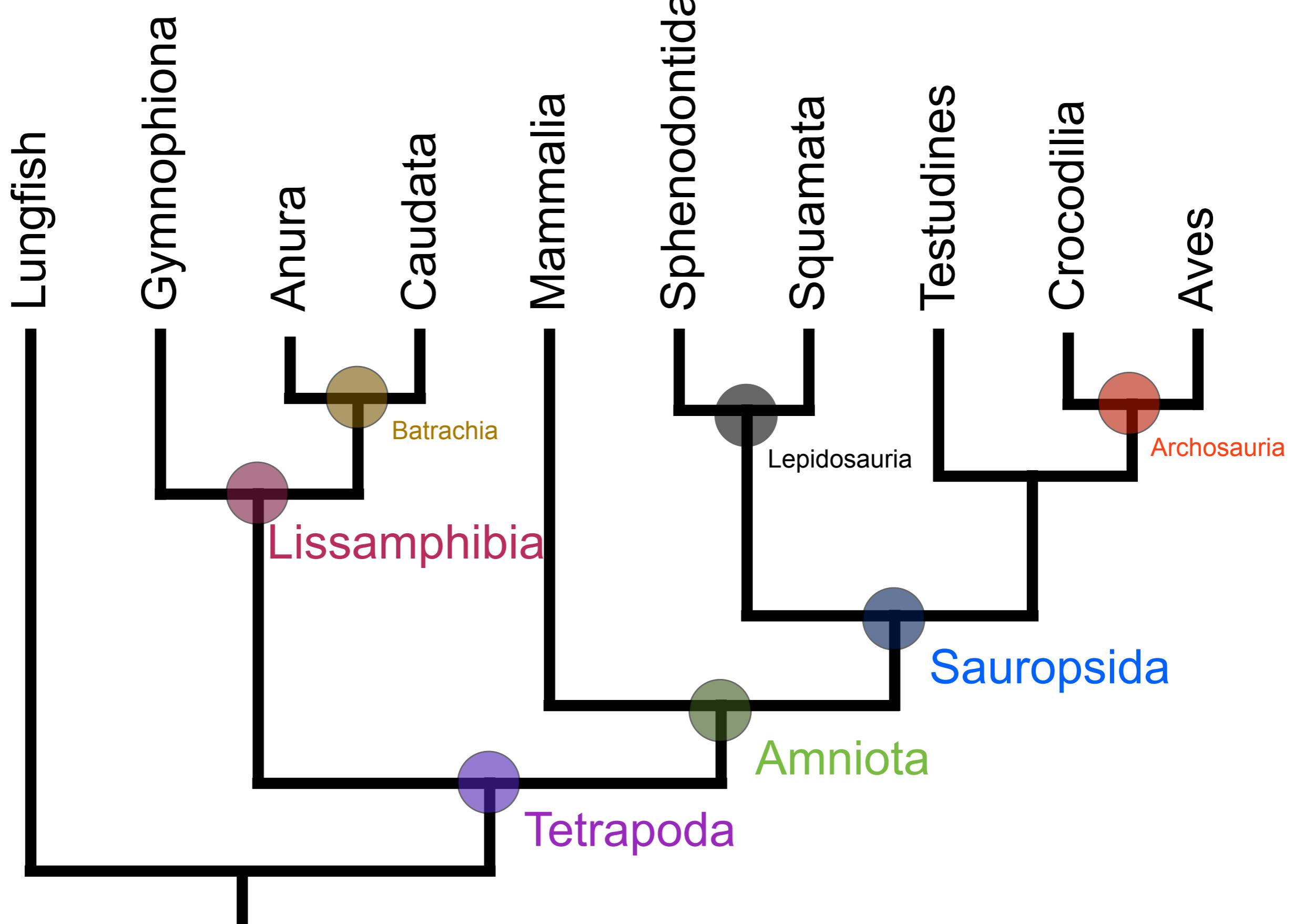
# Archosauria

- Crocodiles, dinosaurs (including birds), and pterosaurs
- 100% awesome

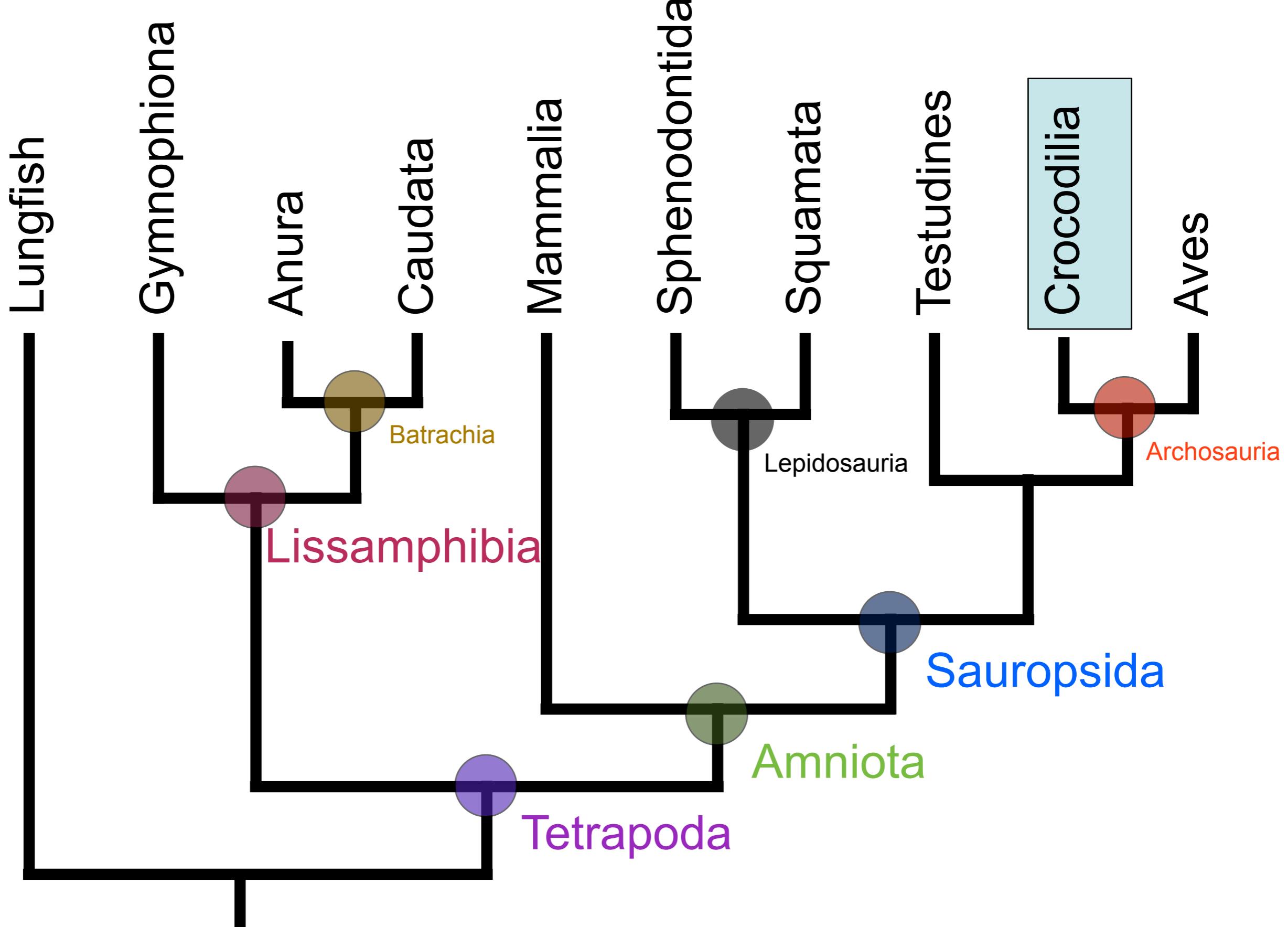




# Systematics of living “herps”



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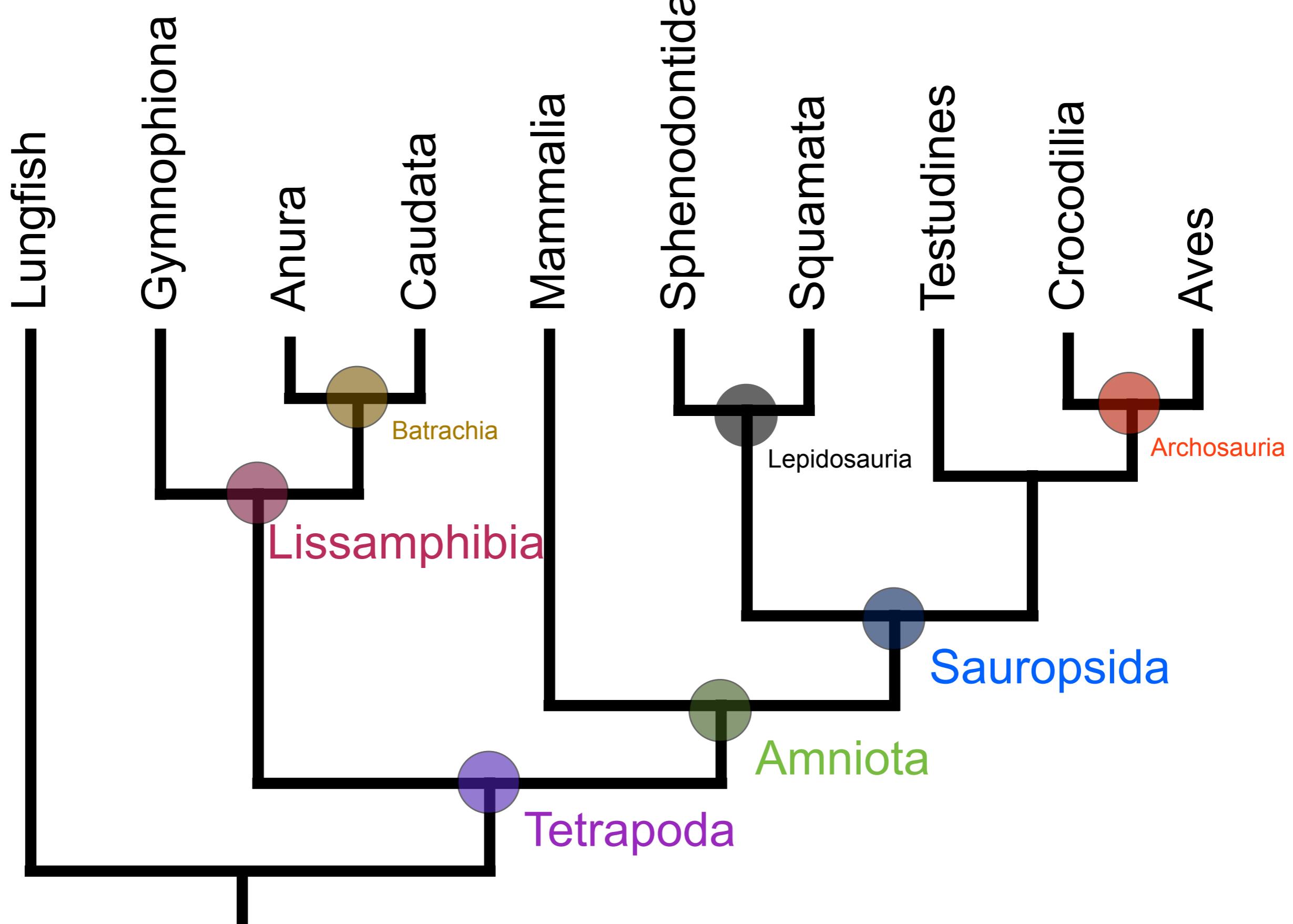
# Crocodilia

- Alligators, caimans, crocodiles, gharials
- 25 species
- Big size range
- Large rivers, swamps, lagoons, ocean

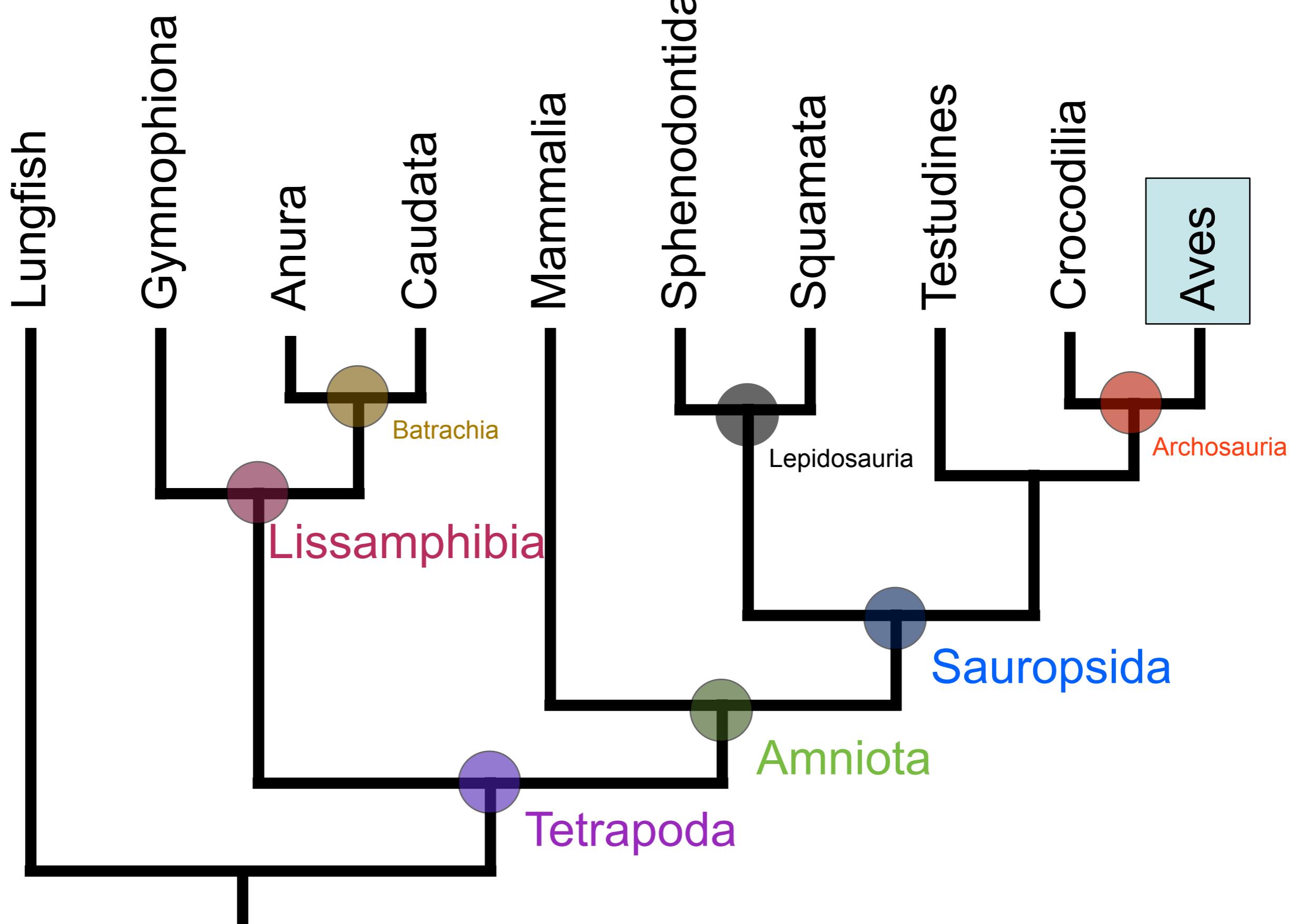
Saltwater Crocodile (*Crocodylus porosus*)



# Systematics of living “herps”



# Systematics of living “herps”



# Aves

- ~10000 species
- Feathers, flight, beaks, homeothermy



# Systematics of living “herps”

